MMAI869_Assign_Q7_Final_FrancisBello

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0.1.1 Individual Assignment, Question 7

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0.1.3 20141658

1 Yum, Orange Juice!

[1]:

```
import datetime
print(datetime.datetime.now())
```

```
2019-11-19 20:52:08.123296
```

Import libraries

[2]:

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.stats import uniform

from sklearn.ensemble import ExtraTreesClassifier
from sklearn.preprocessing import MinMaxScaler
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2
from sklearn.model_selection import train_test_split
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import KFold
from sklearn.model_selection import StratifiedKFold
from sklearn.model_selection import cross_val_score

from sklearn.metrics import confusion_matrix
from sklearn.metrics import f1_score
from sklearn.metrics import accuracy_score
from sklearn.metrics import log_loss
from sklearn.metrics import roc_auc_score
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
from sklearn.metrics import classification_report
from sklearn.preprocessing import LabelEncoder

from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.linear_model import LogisticRegression
from sklearn.svm import SVC
from xgboost import XGBClassifier
```

User-defined functions

[3]:

```
def print_scores(model_name, y_test, y_pred):
    print("Model: " + model_name)
    print("========================================================")
    print("*Accuracy score: " + str(accuracy_score(y_test,y_pred)))
    print("--------------------------------------------------------")
    print("Classification report:")
    print(classification_report(y_test, y_pred))
    print("--------------------------------------------------------")
    print("Confusion matrix:")
    cm = confusion_matrix(y_test,y_pred)
    print(cm)
    print("--------------------------------------------------------")
    print("Precision score: "+ str(precision_score(y_test, y_pred)))
    print("--------------------------------------------------------")
    print("Recall score: " + str(recall_score(y_test, y_pred)))
    print("--------------------------------------------------------")
    print("F1 score: " + str(f1_score(y_test,y_pred)))
    print("--------------------------------------------------------")
    print("Log loss score: " + str(log_loss(y_test,y_pred)))
    print("--------------------------------------------------------")
    print("ROC-AUC score: " + str(roc_auc_score(y_test, y_pred)))
    print("--------------------------------------------------------")
    sensitivity = cm[0,0]/(cm[0,0]+cm[0,1])
    print("Sensitivity score: " + str(sensitivity))
    print("--------------------------------------------------------")
    specificity = cm[1,1]/(cm[1,0]+cm[1,1])
    print("Specificity score: " + str(specificity))
```

[4]:

```
def plot_roc_auc(y_test,y_pred):
    fpr, tpr, _ = roc_curve(y_test, y_pred)

    roc_auc=roc_auc_score(y_test, y_pred)
    plt.figure()
    plt.plot(fpr, tpr, label='ROC curve (area = %0.8f)' % roc_auc)
    plt.plot([0, 1], [0, 1], 'k--')
    plt.xlim([0.0, 1.0])
    plt.ylim([0.0, 1.05])
    plt.xlabel('False Positive Rate')
    plt.ylabel('True Positive Rate')
    plt.title('Receiver operating characteristic')
    plt.legend(loc="lower right")
    plt.show()
```

Read data

[5]:
```
df = pd.read_csv("OJ.csv")
```

Inspect data

[6]:
```
df.head()
```

[6]:
```
   Unnamed: 0 Purchase  WeekofPurchase  StoreID  PriceCH  PriceMM  DiscCH  \
0           1       CH             237        1     1.75     1.99    0.00
1           2       CH             239        1     1.75     1.99    0.00
2           3       CH             245        1     1.86     2.09    0.17
3           4       MM             227        1     1.69     1.69    0.00
4           5       CH             228        7     1.69     1.69    0.00

   DiscMM  SpecialCH  SpecialMM   LoyalCH  SalePriceMM  SalePriceCH  \
0     0.0          0          0  0.500000         1.99         1.75
1     0.3          0          1  0.600000         1.69         1.75
2     0.0          0          0  0.680000         2.09         1.69
3     0.0          0          0  0.400000         1.69         1.69
4     0.0          0          0  0.956535         1.69         1.69

   PriceDiff Store7  PctDiscMM  PctDiscCH  ListPriceDiff  STORE
0       0.24     No   0.000000   0.000000           0.24      1
1      -0.06     No   0.150754   0.000000           0.24      1
2       0.40     No   0.000000   0.091398           0.23      1
3       0.00     No   0.000000   0.000000           0.00      1
4       0.00    Yes   0.000000   0.000000           0.00      0
```

[7]:
```
df.shape
```

[7]:
```
(1070, 19)
```

[8]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1070 entries, 0 to 1069
Data columns (total 19 columns):
Unnamed: 0        1070 non-null int64
```

```
Purchase          1070 non-null object
WeekofPurchase    1070 non-null int64
StoreID           1070 non-null int64
PriceCH           1070 non-null float64
PriceMM           1070 non-null float64
DiscCH            1070 non-null float64
DiscMM            1070 non-null float64
SpecialCH         1070 non-null int64
SpecialMM         1070 non-null int64
LoyalCH           1070 non-null float64
SalePriceMM       1070 non-null float64
SalePriceCH       1070 non-null float64
PriceDiff         1070 non-null float64
Store7            1070 non-null object
PctDiscMM         1070 non-null float64
PctDiscCH         1070 non-null float64
ListPriceDiff     1070 non-null float64
STORE             1070 non-null int64
dtypes: float64(11), int64(6), object(2)
memory usage: 158.9+ KB
```

```
[9]: df.describe().transpose()
```

```
[9]:                  count        mean         std         min         25%  \
     Unnamed: 0      1070.0  535.500000  309.026698    1.000000  268.250000
     WeekofPurchase  1070.0  254.381308   15.558286  227.000000  240.000000
     StoreID         1070.0    3.959813    2.308984    1.000000    2.000000
     PriceCH         1070.0    1.867421    0.101970    1.690000    1.790000
     PriceMM         1070.0    2.085411    0.134386    1.690000    1.990000
     DiscCH          1070.0    0.051860    0.117474    0.000000    0.000000
     DiscMM          1070.0    0.123364    0.213834    0.000000    0.000000
     SpecialCH       1070.0    0.147664    0.354932    0.000000    0.000000
     SpecialMM       1070.0    0.161682    0.368331    0.000000    0.000000
     LoyalCH         1070.0    0.565782    0.307843    0.000011    0.325257
     SalePriceMM     1070.0    1.962047    0.252697    1.190000    1.690000
     SalePriceCH     1070.0    1.815561    0.143384    1.390000    1.750000
     PriceDiff       1070.0    0.146486    0.271563   -0.670000    0.000000
     PctDiscMM       1070.0    0.059298    0.101760    0.000000    0.000000
     PctDiscCH       1070.0    0.027314    0.062232    0.000000    0.000000
     ListPriceDiff   1070.0    0.217991    0.107535    0.000000    0.140000
     STORE           1070.0    1.630841    1.430387    0.000000    0.000000

                        50%         75%          max
     Unnamed: 0      535.50  802.750000  1070.000000
     WeekofPurchase  257.00  268.000000   278.000000
     StoreID           3.00    7.000000     7.000000
     PriceCH           1.86    1.990000     2.090000
```

```
PriceMM          2.09    2.180000     2.290000
DiscCH           0.00    0.000000     0.500000
DiscMM           0.00    0.230000     0.800000
SpecialCH        0.00    0.000000     1.000000
SpecialMM        0.00    0.000000     1.000000
LoyalCH          0.60    0.850873     0.999947
SalePriceMM      2.09    2.130000     2.290000
SalePriceCH      1.86    1.890000     2.090000
PriceDiff        0.23    0.320000     0.640000
PctDiscMM        0.00    0.112676     0.402010
PctDiscCH        0.00    0.000000     0.252688
ListPriceDiff    0.24    0.300000     0.440000
STORE            2.00    3.000000     4.000000
```

Drop features that serve as identification purposes only, don't contribute to predction

```
[10]: df_clean = df.drop(['Unnamed: 0','WeekofPurchase','STORE','StoreID'], axis=1)
      df_clean.head()
```

```
[10]:   Purchase  PriceCH  PriceMM  DiscCH  DiscMM  SpecialCH  SpecialMM   LoyalCH  \
      0       CH     1.75     1.99    0.00     0.0          0          0  0.500000
      1       CH     1.75     1.99    0.00     0.3          0          1  0.600000
      2       CH     1.86     2.09    0.17     0.0          0          0  0.680000
      3       MM     1.69     1.69    0.00     0.0          0          0  0.400000
      4       CH     1.69     1.69    0.00     0.0          0          0  0.956535

         SalePriceMM  SalePriceCH  PriceDiff Store7  PctDiscMM  PctDiscCH  \
      0         1.99         1.75       0.24     No   0.000000   0.000000
      1         1.69         1.75      -0.06     No   0.150754   0.000000
      2         2.09         1.69       0.40     No   0.000000   0.091398
      3         1.69         1.69       0.00     No   0.000000   0.000000
      4         1.69         1.69       0.00    Yes   0.000000   0.000000

         ListPriceDiff
      0           0.24
      1           0.24
      2           0.23
      3           0.00
      4           0.00
```

Change string or 1/0 values to Python-accepted values

```
[11]: Store7_dict = {'Yes': True, 'No': False}
      SpecialCH_dict = {1: True, 0: False}
      SpecialMM_dict = {1: True, 0: False}
      df_clean.Store7 = [Store7_dict[item] for item in df_clean.Store7]
      df_clean.SpecialCH = [SpecialCH_dict[item] for item in df_clean.SpecialCH]
      df_clean.SpecialMM = [SpecialMM_dict[item] for item in df_clean.SpecialMM]
      df_clean.head()
```

```
[11]:   Purchase  PriceCH  PriceMM  DiscCH  DiscMM  SpecialCH  SpecialMM   LoyalCH  \
      0       CH     1.75     1.99    0.00     0.0      False      False  0.500000
      1       CH     1.75     1.99    0.00     0.3      False       True  0.600000
      2       CH     1.86     2.09    0.17     0.0      False      False  0.680000
      3       MM     1.69     1.69    0.00     0.0      False      False  0.400000
      4       CH     1.69     1.69    0.00     0.0      False      False  0.956535

         SalePriceMM  SalePriceCH  PriceDiff  Store7  PctDiscMM  PctDiscCH  \
      0         1.99         1.75       0.24   False   0.000000   0.000000
      1         1.69         1.75      -0.06   False   0.150754   0.000000
      2         2.09         1.69       0.40   False   0.000000   0.091398
      3         1.69         1.69       0.00   False   0.000000   0.000000
      4         1.69         1.69       0.00    True   0.000000   0.000000

         ListPriceDiff
      0           0.24
      1           0.24
      2           0.23
      3           0.00
      4           0.00
```

Separate predictors from target

```
[12]: X = df_clean.iloc[:,1:] #get independent features
      y = df_clean.iloc[:,0] #get target feature
```

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

```
[13]:    PriceCH  PriceMM  DiscCH  DiscMM  SpecialCH  SpecialMM   LoyalCH  \
      0     1.75     1.99    0.00     0.0      False      False  0.500000
      1     1.75     1.99    0.00     0.3      False       True  0.600000
      2     1.86     2.09    0.17     0.0      False      False  0.680000
      3     1.69     1.69    0.00     0.0      False      False  0.400000
      4     1.69     1.69    0.00     0.0      False      False  0.956535

         SalePriceMM  SalePriceCH  PriceDiff  Store7  PctDiscMM  PctDiscCH  \
      0         1.99         1.75       0.24   False   0.000000   0.000000
      1         1.69         1.75      -0.06   False   0.150754   0.000000
      2         2.09         1.69       0.40   False   0.000000   0.091398
      3         1.69         1.69       0.00   False   0.000000   0.000000
      4         1.69         1.69       0.00    True   0.000000   0.000000

         ListPriceDiff
      0           0.24
```

```
1            0.24
2            0.23
3            0.00
4            0.00
```

[14]:
```
y.head()
```

[14]:
```
0    CH
1    CH
2    CH
3    MM
4    CH
Name: Purchase, dtype: object
```

Encode target feature's string values to numeric

[15]:
```
le_Purchase = LabelEncoder()

y[:] = le_Purchase.fit_transform(y[:]) # CH => 0, MM => 1
y.head()
```

```
C:\Users\Owner\Anaconda3\lib\site-packages\ipykernel_launcher.py:3:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: http://pandas.pydata.org/pandas-
docs/stable/indexing.html#indexing-view-versus-copy
  This is separate from the ipykernel package so we can avoid doing imports
until
```

[15]:
```
0    0
1    0
2    0
3    1
4    0
Name: Purchase, dtype: int32
```

Drop calculated-information features

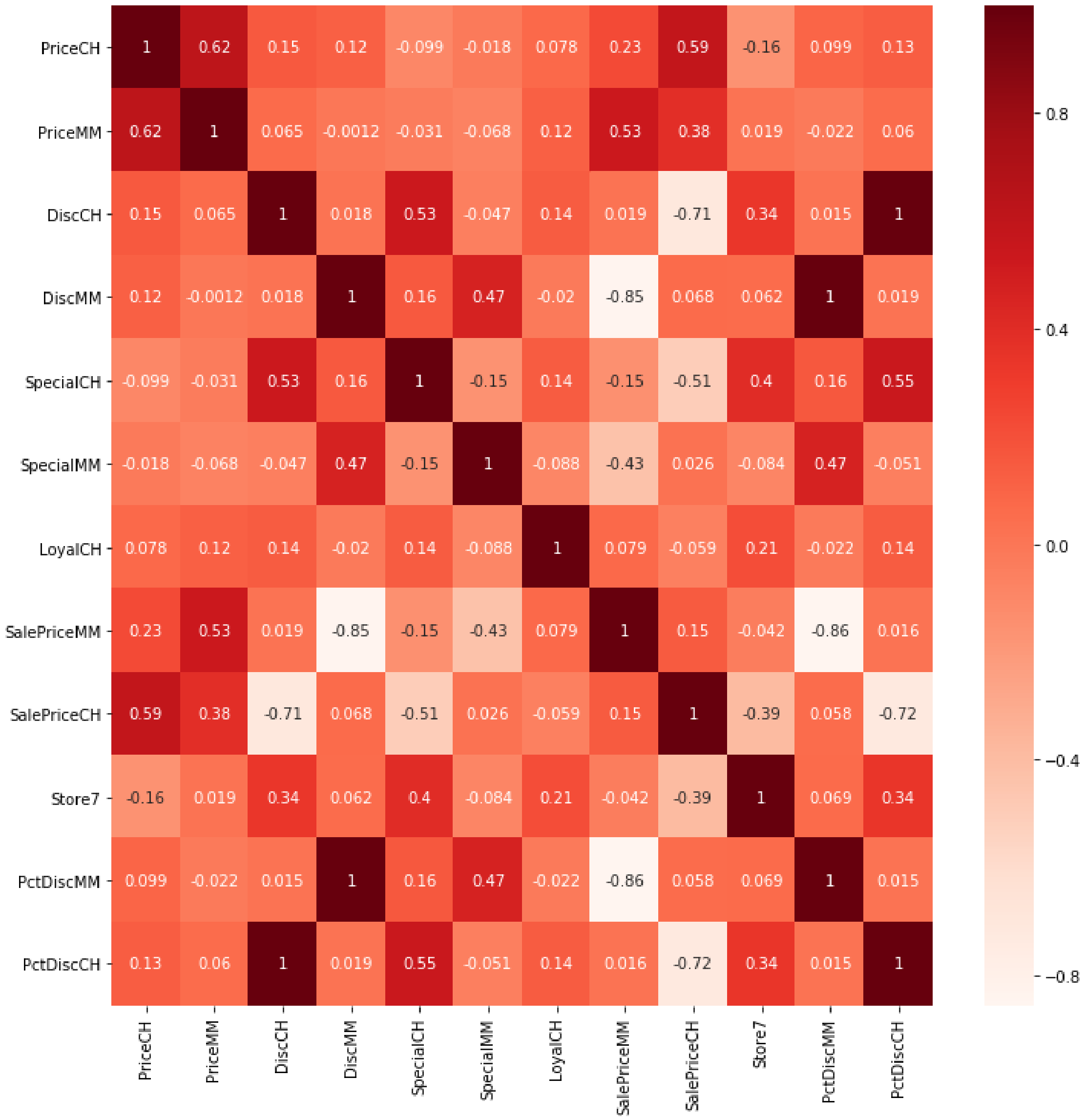
[16]:
```
X = X.drop(['PriceDiff','ListPriceDiff'], axis=1)
X.head()
```

[16]:
```
   PriceCH  PriceMM  DiscCH  DiscMM  SpecialCH  SpecialMM   LoyalCH  \
0     1.75     1.99    0.00     0.0      False      False  0.500000
1     1.75     1.99    0.00     0.3      False       True  0.600000
2     1.86     2.09    0.17     0.0      False      False  0.680000
3     1.69     1.69    0.00     0.0      False      False  0.400000
4     1.69     1.69    0.00     0.0      False      False  0.956535
```

```
   SalePriceMM  SalePriceCH  Store7  PctDiscMM  PctDiscCH
0         1.99         1.75   False   0.000000   0.000000
1         1.69         1.75   False   0.150754   0.000000
2         2.09         1.69   False   0.000000   0.091398
3         1.69         1.69   False   0.000000   0.000000
4         1.69         1.69    True   0.000000   0.000000
```

Check for correlated features

[17]:
```
plt.figure(figsize=(12,12))
cor = X.corr()
sns.heatmap(cor, annot=True, cmap=plt.cm.Reds)
plt.show()
```



Check for features importance

[19]:

```
n = 12
bestfeatures = SelectKBest(score_func=chi2,k=n)
fit = bestfeatures.fit(X,y)

dfscores = pd.DataFrame(fit.scores_) #save scores as pandas dataframe
dfcolumns = pd.DataFrame(X.columns) #save columns as pandas dataframe
featureScores = pd.concat([dfcolumns,dfscores],axis=1)
featureScores.columns = ['Feature','Score']

#print all features, ranked from highest to lowest
with pd.option_context('display.max_rows',None, 'display.max_columns',None):
    print(featureScores.nlargest(n,'Score'))
```

```
        Feature      Score
6       LoyalCH  73.474324
9        Store7  38.023303
5     SpecialMM  27.402799
4     SpecialCH  16.072116
3        DiscMM  11.039877
2        DiscCH   9.345082
10    PctDiscMM   5.172507
11    PctDiscCH   5.031893
7   SalePriceMM   1.692854
8   SalePriceCH   0.211320
1       PriceMM   0.206022
0       PriceCH   0.003154
```

[20]:

```
bestfeatures = ExtraTreesClassifier()
bestfeatures.fit(X,y)
print(bestfeatures.feature_importances_)
```

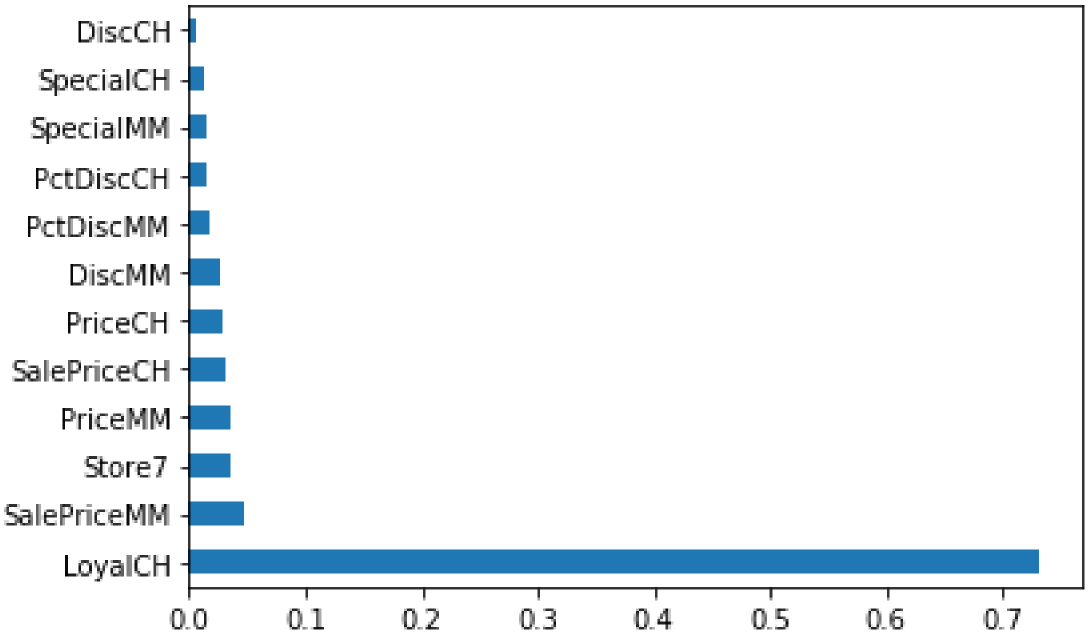
```
[0.02800074 0.03455771 0.00662119 0.02611937 0.01353585 0.01391939
 0.73209098 0.04612831 0.03217593 0.03459103 0.01632134 0.01593816]
```

```
C:\Users\Owner\Anaconda3\lib\site-packages\sklearn\ensemble\forest.py:245:
FutureWarning: The default value of n_estimators will change from 10 in version
0.20 to 100 in 0.22.
  "10 in version 0.20 to 100 in 0.22.", FutureWarning)
```

[23]:

```
#plot to visualize
n=15
feat_importances = pd.Series(bestfeatures.feature_importances_,index=X.columns)
feat_importances.nlargest(n).plot(kind='barh')
plt.show()
```

```
with pd.option_context('display.max_rows',None, 'display.max_columns',None):
    print(feat_importances.nlargest(n=n, keep = 'first'))
```



```
LoyalCH        0.732091
SalePriceMM    0.046128
Store7         0.034591
PriceMM        0.034558
SalePriceCH    0.032176
PriceCH        0.028001
DiscMM         0.026119
PctDiscMM      0.016321
PctDiscCH      0.015938
SpecialMM      0.013919
SpecialCH      0.013536
DiscCH         0.006621
dtype: float64
```

Drop a feature that is correlated with another

```
[24]: X = X.drop(['PctDiscMM','PctDiscCH'], axis=1)
```

View final form of data sets

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

```
[25]:    PriceCH  PriceMM  DiscCH  DiscMM  SpecialCH  SpecialMM   LoyalCH  \
      0     1.75     1.99    0.00     0.0      False      False  0.500000
```

```
1     1.75     1.99    0.00     0.3     False       True   0.600000
2     1.86     2.09    0.17     0.0     False      False   0.680000
3     1.69     1.69    0.00     0.0     False      False   0.400000
4     1.69     1.69    0.00     0.0     False      False   0.956535

   SalePriceMM  SalePriceCH  Store7
0         1.99         1.75   False
1         1.69         1.75   False
2         2.09         1.69   False
3         1.69         1.69   False
4         1.69         1.69    True
```

```
[26]: X.shape
```

```
[26]: (1070, 10)
```

```
[27]: y.head()
```

```
[27]: 0    0
      1    0
      2    0
      3    1
      4    0
      Name: Purchase, dtype: int32
```

```
[28]: y.describe()
```

```
[28]: count    1070.000000
      mean        0.389720
      std         0.487915
      min         0.000000
      25%         0.000000
      50%         0.000000
      75%         1.000000
      max         1.000000
      Name: Purchase, dtype: float64
```

```
[29]: y.shape
```

```
[29]: (1070,)
```

Copy predictors and target features for use in KFold, Strat KFold, CrossVal, RandomizedSearchCV

```
[30]: #Decision Tree
      X_DT_KF, y_DT_KF = X, y
      X_DT_SKF, y_DT_SKF = X, y
```

```
X_DT_CV, y_DT_CV = X, y

#Random Forest
X_RF_KF, y_RF_KF = X, y
X_RF_SKF, y_RF_SKF = X, y
X_RF_CV, y_RF_CV = X, y

#logistic Regression
X_LR_KF, y_LR_KF = X, y
X_LR_SKF, y_LR_SKF = X, y
X_LR_CV, y_LR_CV = X, y

#Support Vector Machine
X_SVM_KF, y_SVM_KF = X, y
X_SVM_SKF, y_SVM_SKF = X, y
X_SVM_CV, y_SVM_CV = X, y

#XGBoost
X_XGB_KF, y_XGB_KF = X, y
X_XGB_SKF, y_XGB_SKF = X, y
X_XGB_CV, y_XGB_CV = X, y


#RandomizedSearchCV()
X_GSCV_DT, y_GSCV_DT  = X, y
X_GSCV_RF, y_GSCV_RF  = X, y
X_GSCV_LR, y_GSCV_LR  = X, y
X_GSCV_SVM, y_GSCV_SVM  = X, y
X_GSCV_XGB, y_GSCV_XGB  = X, y
```

Split between train and test sets

[31]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,␣
 ↪random_state=42)
```

1.0.1 1. Decision Tree

Determine best parameters for a Decision Tree classifier

[32]:

```
criterion_options=["gini","entropy"]
splitter_options=["best","random"]
max_features_options=["auto","sqrt","log2"]
min_samples_split_range=list(range(2,5))
min_samples_leaf_range=list(range(1,5))
random_state_range=[42]
min_weight_fraction_leaf_range=[0,0.5]
min_impurity_decrease_range=uniform(0,1)

```

```
param_grid = dict(
                    criterion=criterion_options,
                    splitter=splitter_options,
                    max_features=max_features_options,
                    min_samples_split=min_samples_split_range,
                    min_samples_leaf=min_samples_leaf_range,
                    random_state=random_state_range,
                    min_weight_fraction_leaf=min_weight_fraction_leaf_range,
                    min_impurity_decrease=min_impurity_decrease_range
                  )

cross_val = DecisionTreeClassifier()
grid = RandomizedSearchCV(cross_val, param_grid, random_state=42, n_iter=45,␣
 ↪cv=10, scoring='accuracy', verbose=0)
%time grid.fit(X_GSCV_DT,y_GSCV_DT)

print (grid.best_score_)
print (grid.best_params_)
print (grid.best_estimator_)
```

```
Wall time: 4.87 s
0.6102803738317757
{'criterion': 'gini', 'max_features': 'auto', 'min_impurity_decrease':
0.1834347898661638, 'min_samples_leaf': 4, 'min_samples_split': 2,
'min_weight_fraction_leaf': 0, 'random_state': 42, 'splitter': 'best'}
DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                       max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.1834347898661638,
                       min_impurity_split=None, min_samples_leaf=4,
                       min_samples_split=2, min_weight_fraction_leaf=0,
                       presort=False, random_state=42, splitter='best')
```

Create a Decision Tree classifier

[33]:
```
model=DecisionTreeClassifier(class_weight=None, criterion='gini',␣
 ↪max_depth=None,
                       max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.1834347898661638,
                       min_impurity_split=None, min_samples_leaf=4,
                       min_samples_split=2, min_weight_fraction_leaf=0,
                       presort=False, random_state=42, splitter='best')
```

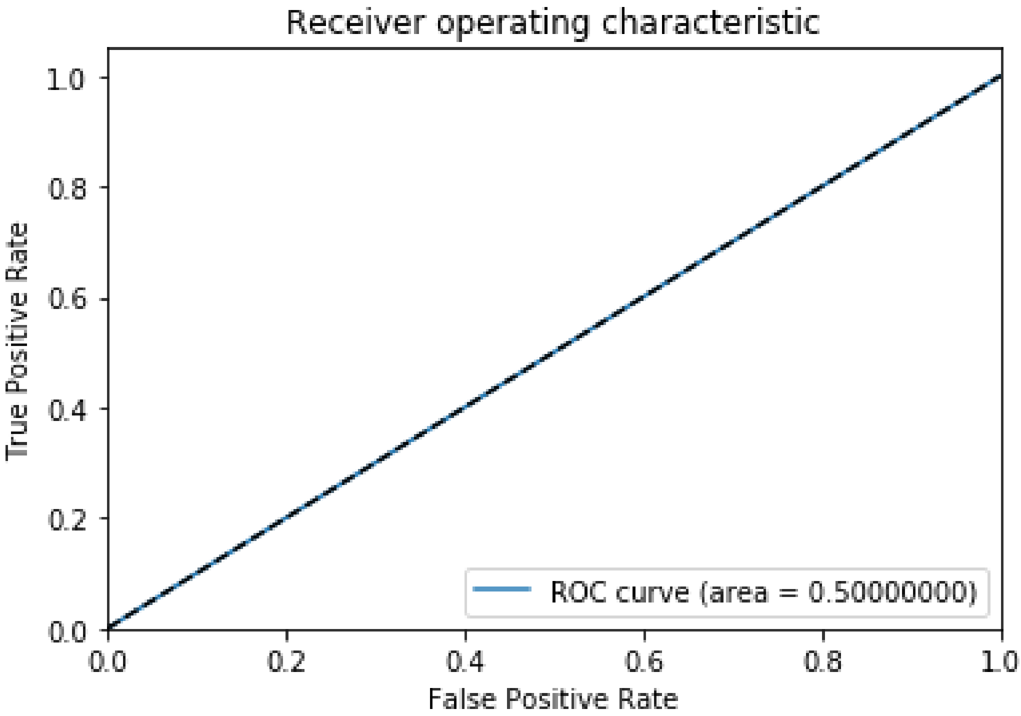
Train using K Fold

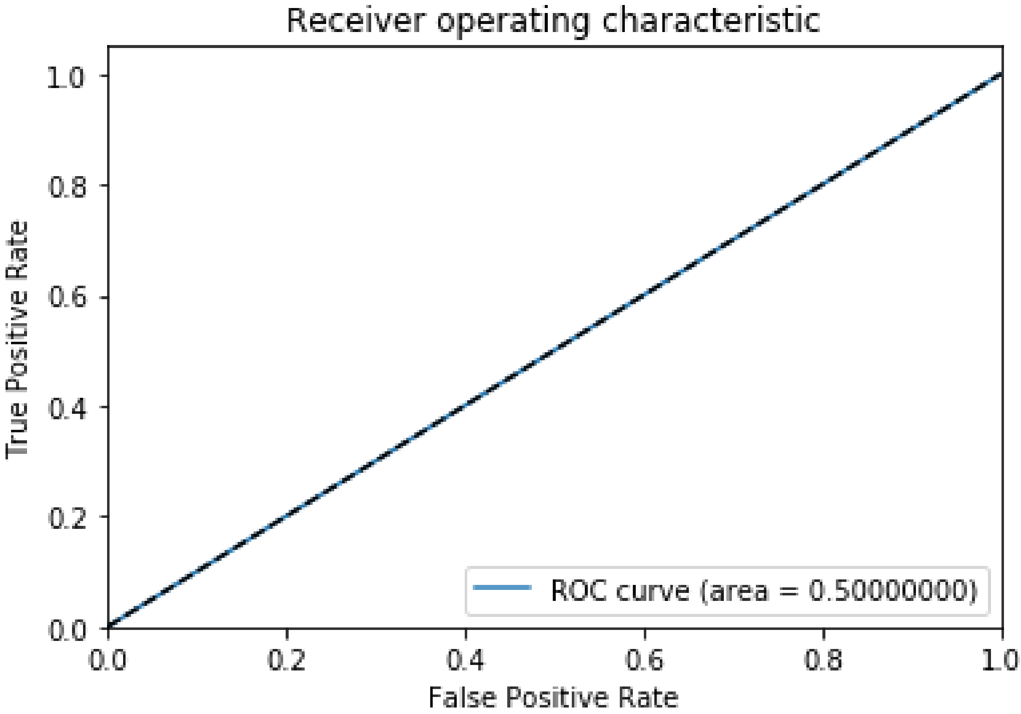
[34]:
```
accuracy_DT_KF=[]
roc_auc_DT_KF=[]
```

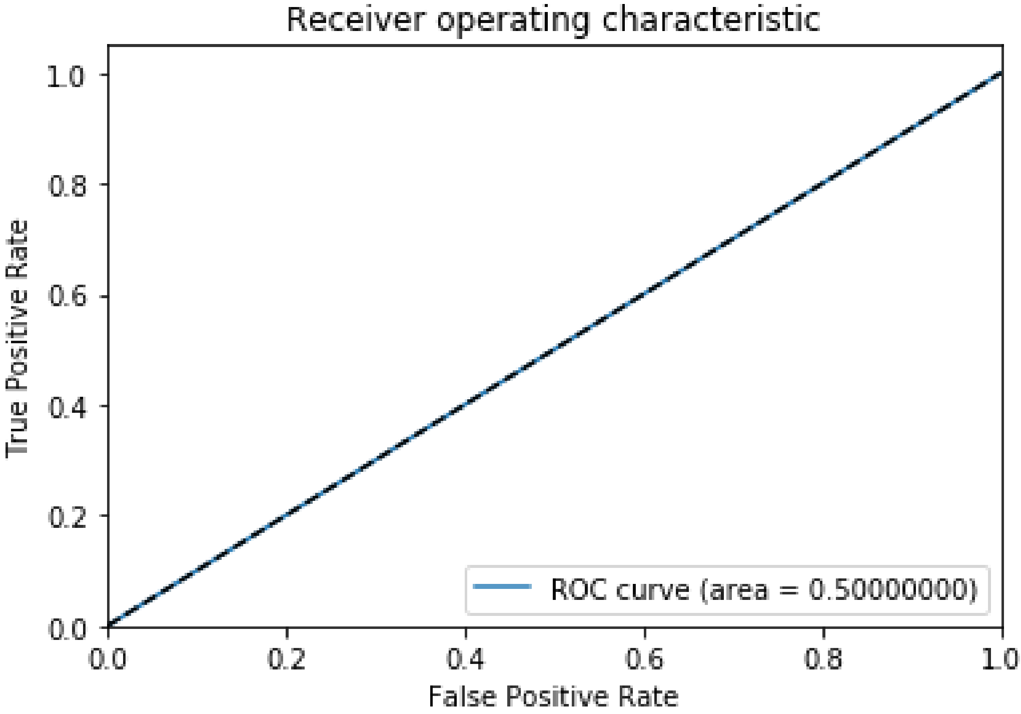
[35]:
```
kf_DT = KFold(n_splits=10,random_state=42)
```

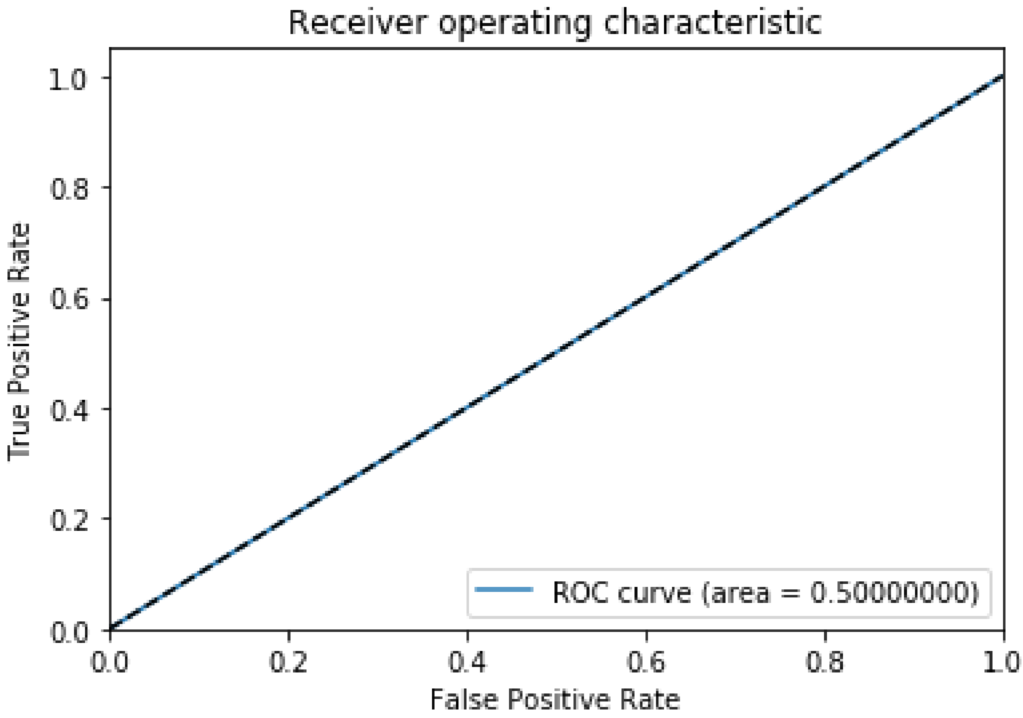
[36]:

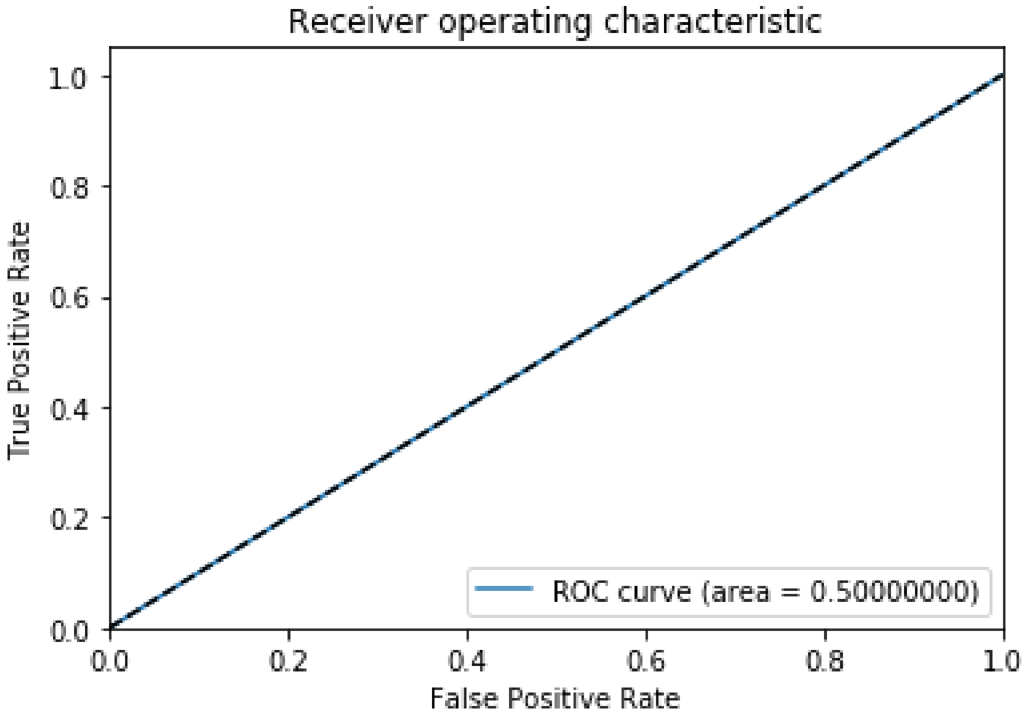
```
for train_index,test_index in kf_DT.split(X_DT_KF,y_DT_KF):
    X_train_DT_KF,X_test_DT_KF,y_train_DT_KF,y_test_DT_KF = X_DT_KF.
 ↪iloc[train_index],X_DT_KF.iloc[test_index],y_DT_KF.iloc[train_index],y_DT_KF.
 ↪iloc[test_index]

    model.fit(X_train_DT_KF,y_train_DT_KF)
    y_pred = model.predict(X_test_DT_KF)
    score=accuracy_score(y_pred,y_test_DT_KF)
    accuracy_DT_KF.append(score)
    roc_auc_DT_KF.append(roc_auc_score(y_test_DT_KF,y_pred))
    plot_roc_auc(y_test_DT_KF,y_pred)
```

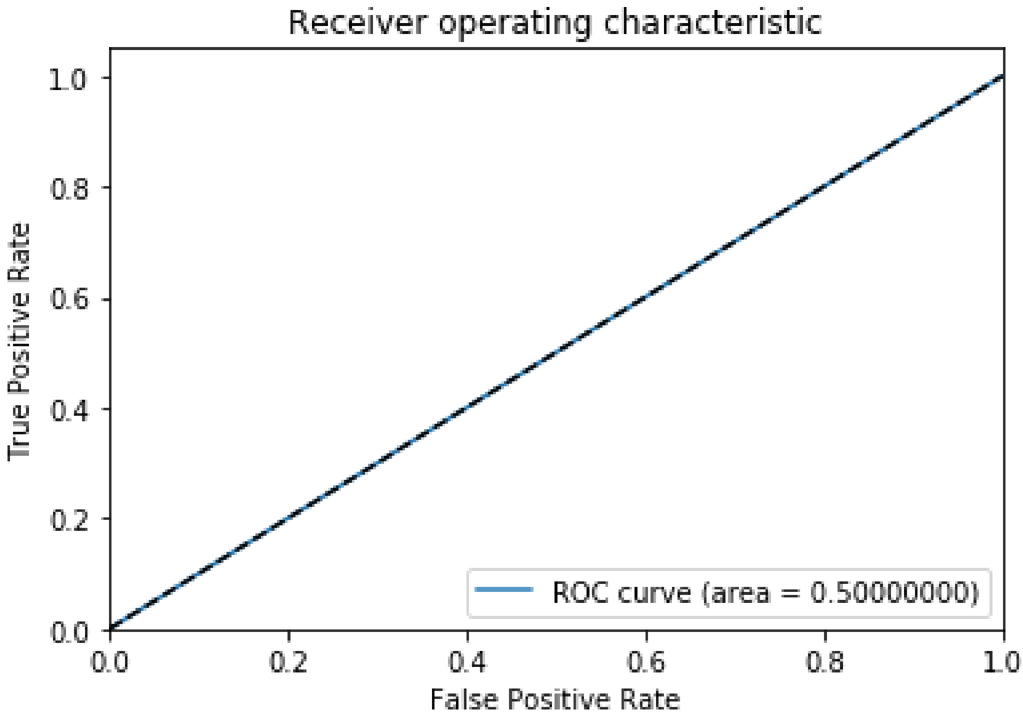


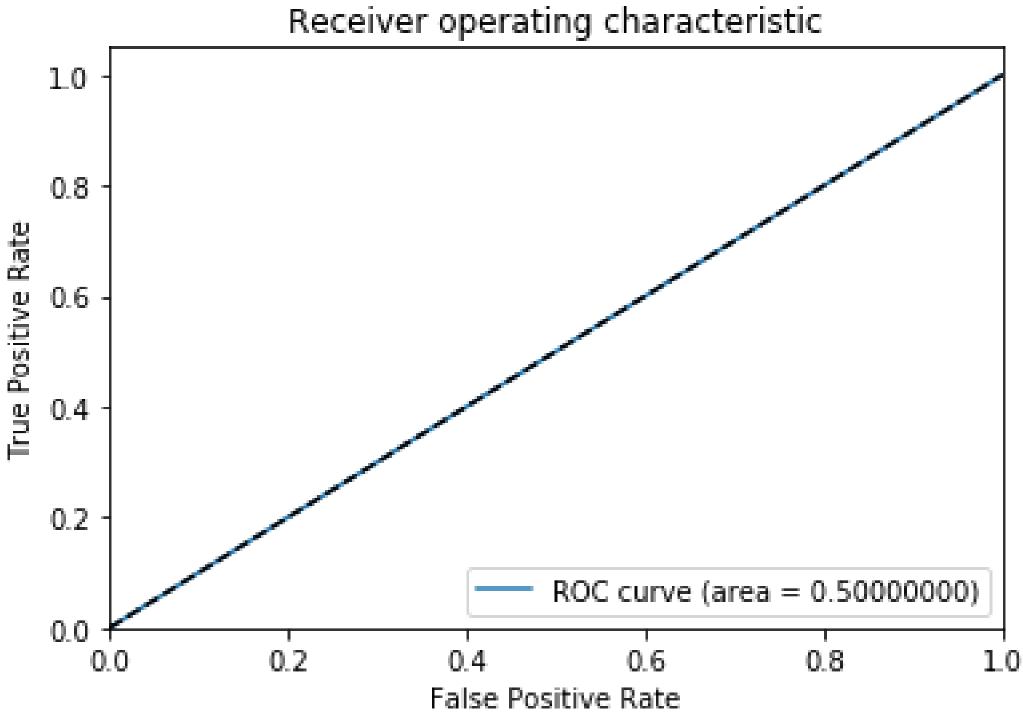

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

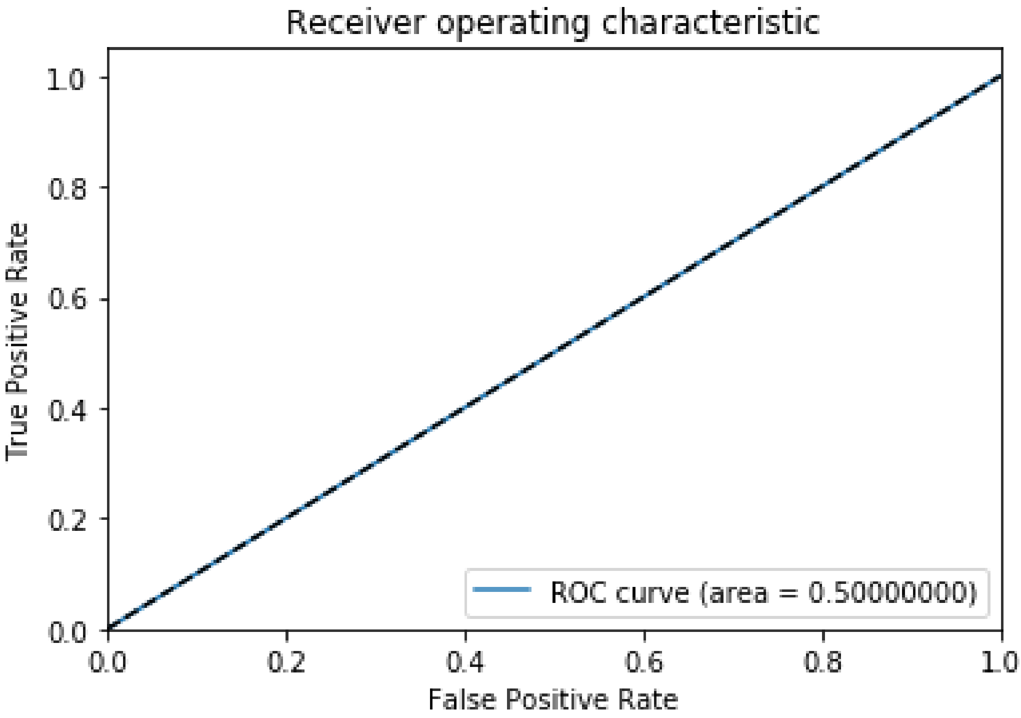

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

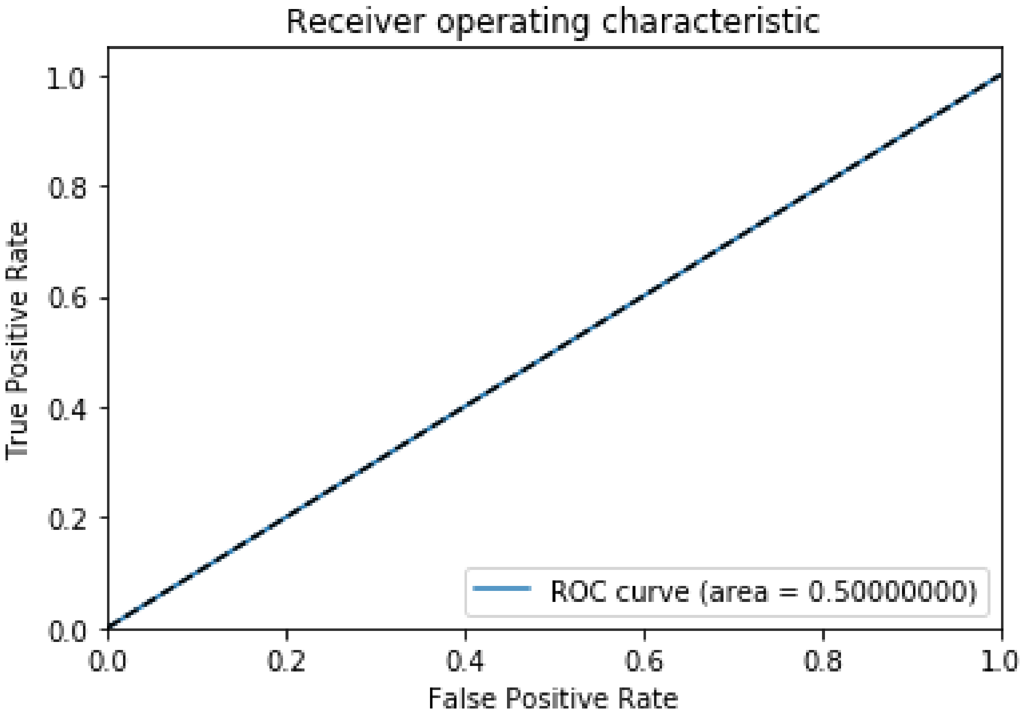

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

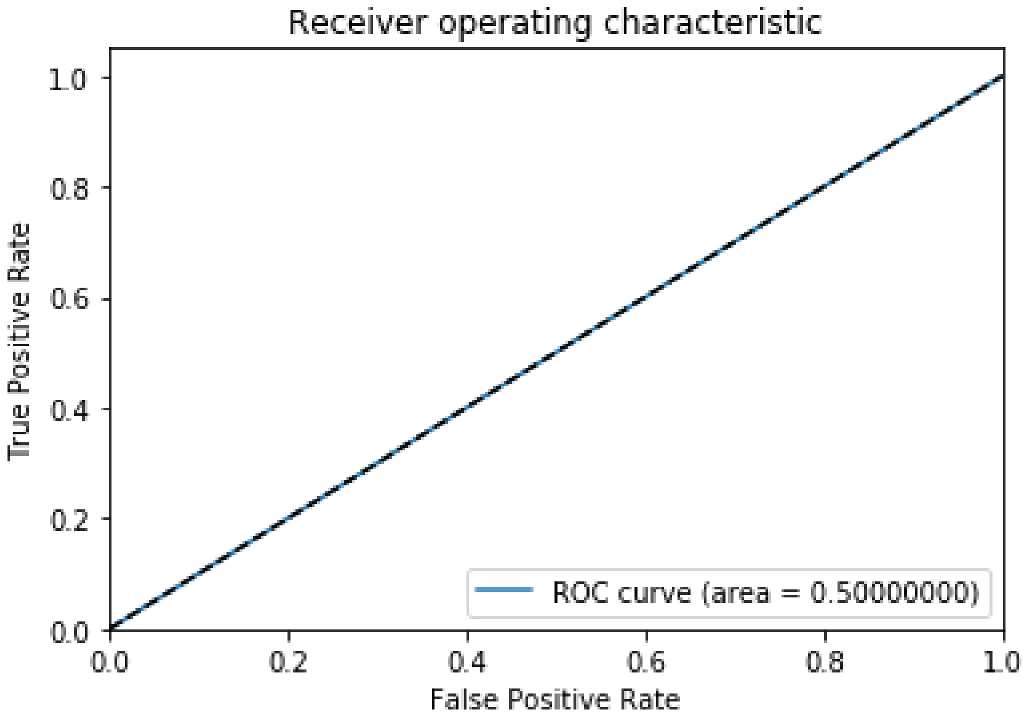

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
1.0
0.8
0.6
0.4
0.2
0.0
True Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
ROC curve (area = 0.50000000)


Receiver operating characteristic
1.0
0.8
0.6
0.4
0.2
0.0
True Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

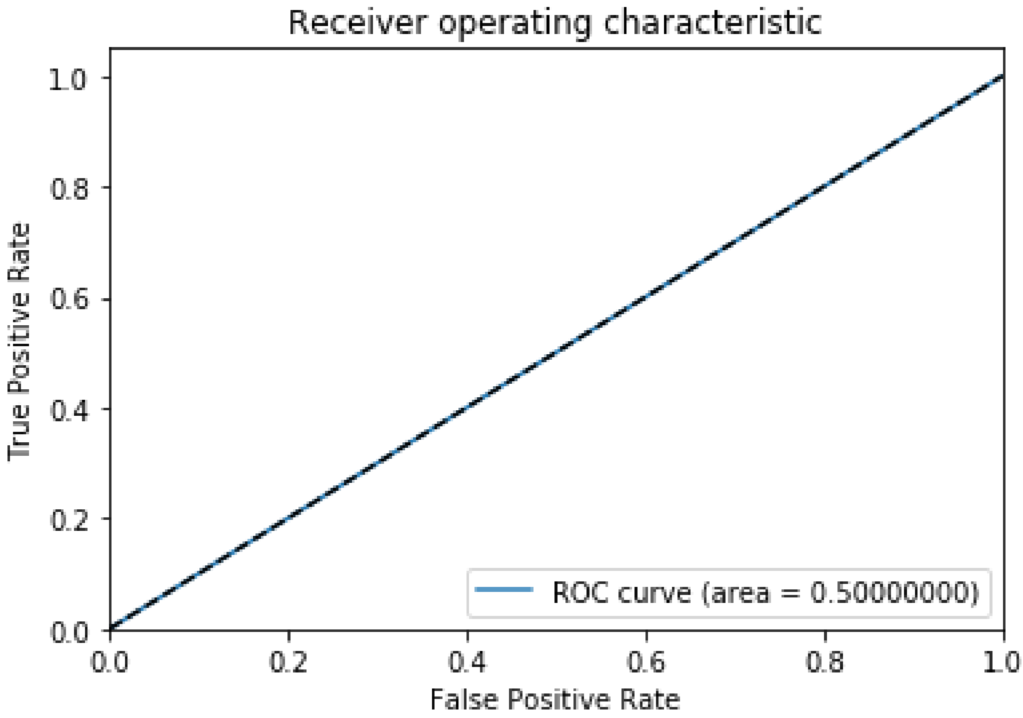


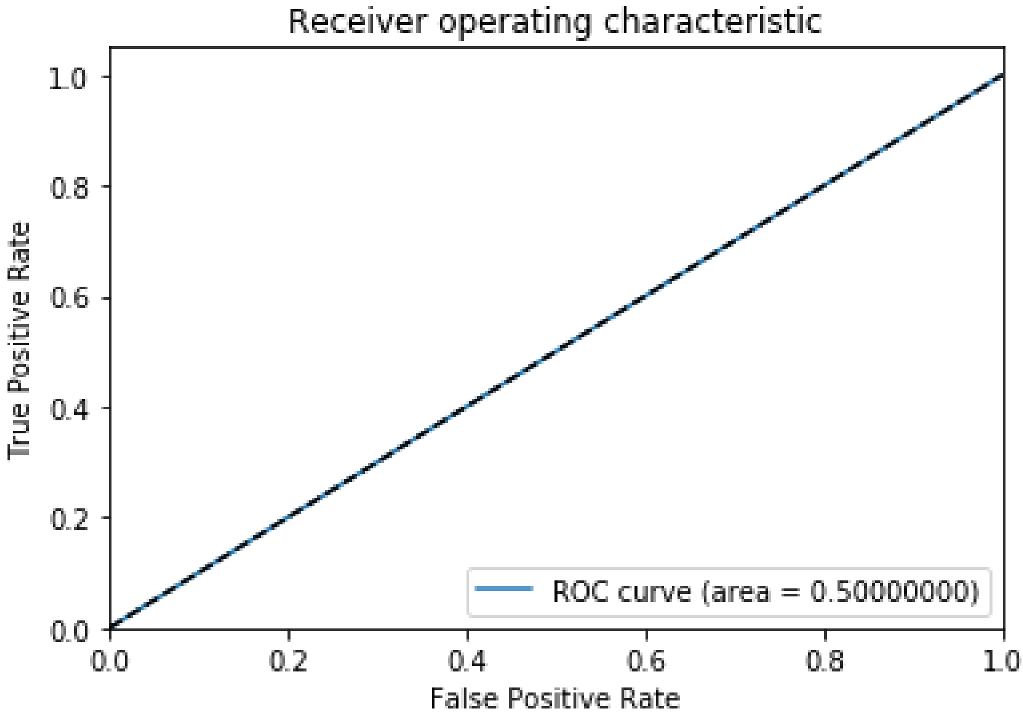
Train using Stratified K Fold

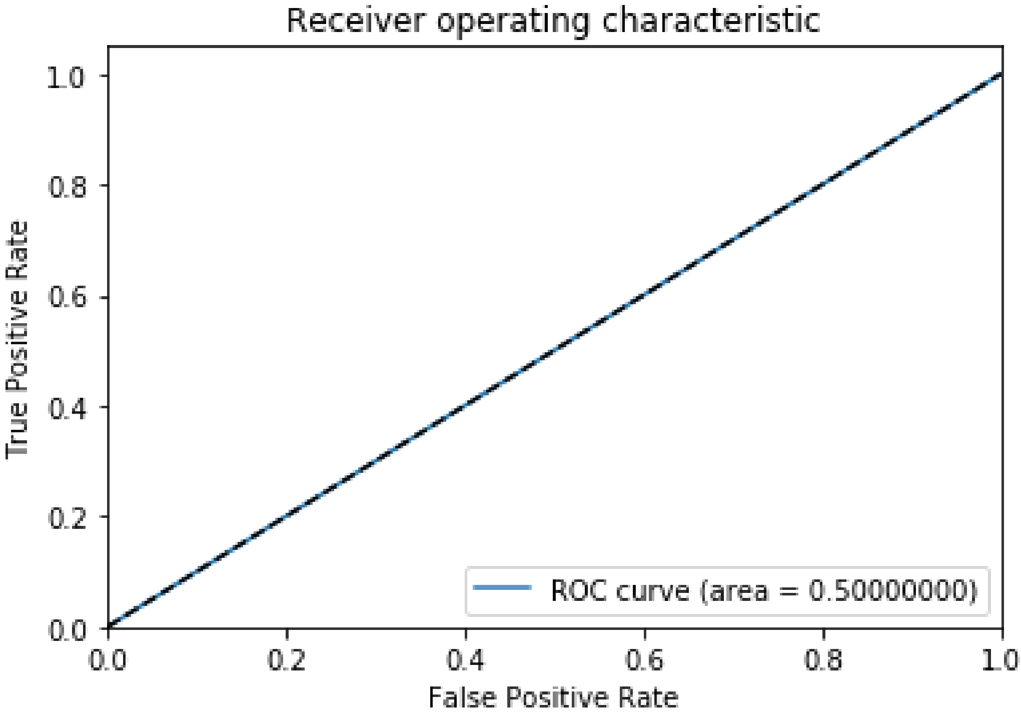
[37]:
```
accuracy_DT_SKF=[]
roc_auc_DT_SKF=[]
```

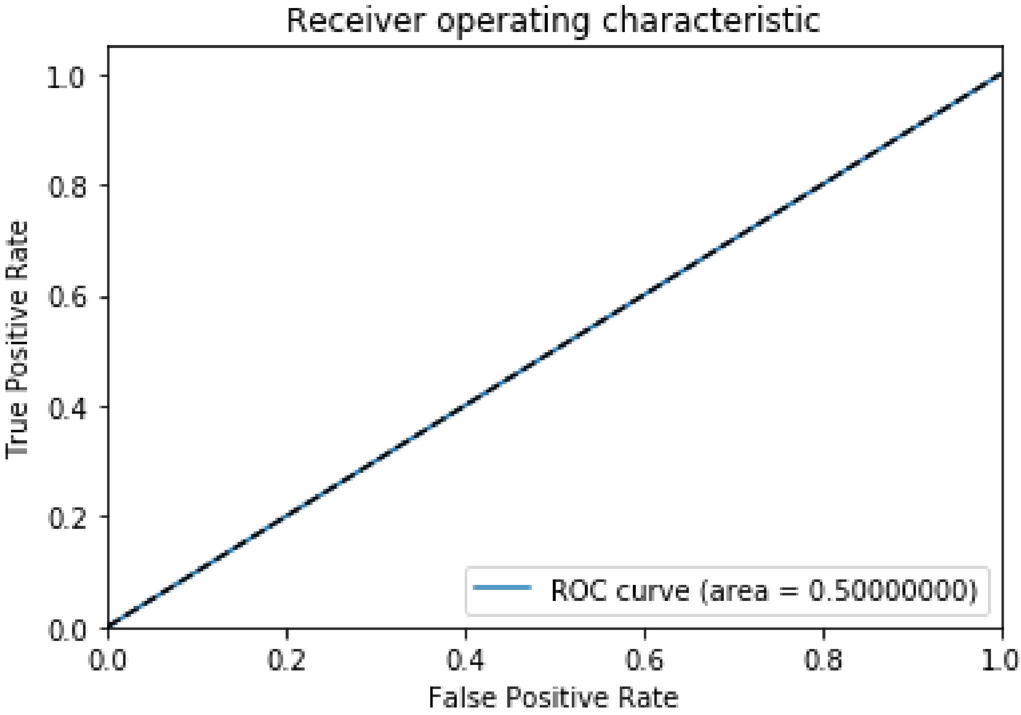
[38]:
```
skf_DT = StratifiedKFold(n_splits=10,random_state=42)
```

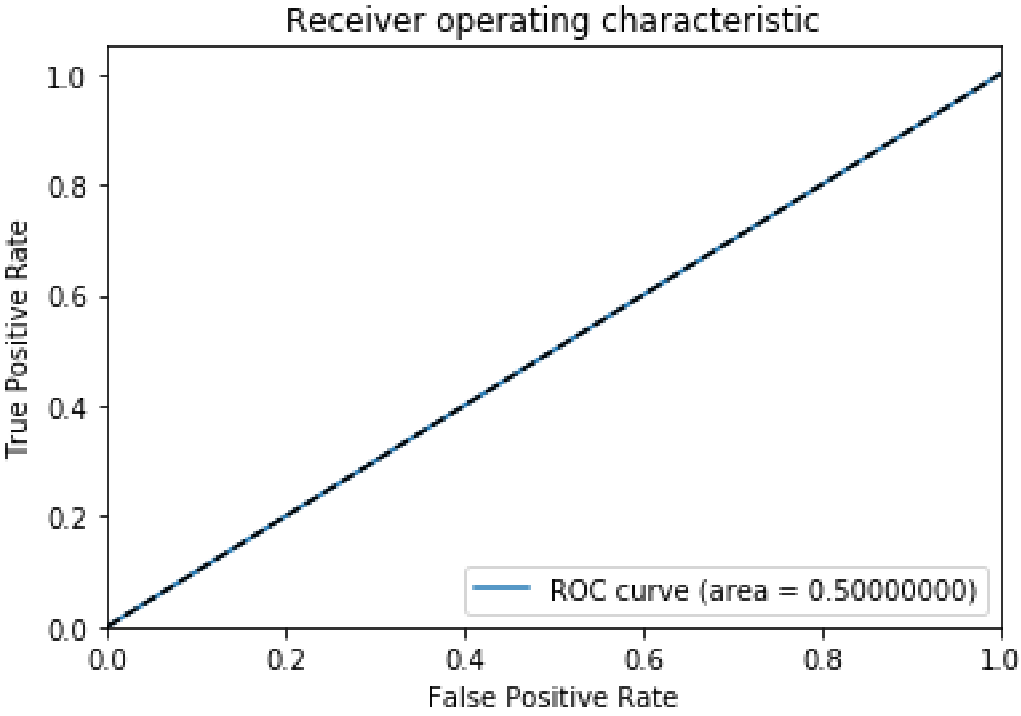
[39]:
```
for train_index,test_index in skf_DT.split(X_DT_SKF,y_DT_SKF):
    X_train_DT_SKF,X_test_DT_SKF,y_train_DT_SKF,y_test_DT_SKF = X_DT_SKF.
 ↪iloc[train_index],X_DT_SKF.iloc[test_index],y_DT_SKF.
 ↪iloc[train_index],y_DT_SKF.iloc[test_index]

    model.fit(X_train_DT_SKF,y_train_DT_SKF)
    y_pred = model.predict(X_test_DT_SKF)
    score=accuracy_score(y_pred,y_test_DT_SKF)
    accuracy_DT_SKF.append(score)
    roc_auc_DT_SKF.append(roc_auc_score(y_test_DT_SKF,y_pred))
    plot_roc_auc(y_test_DT_SKF,y_pred)
```

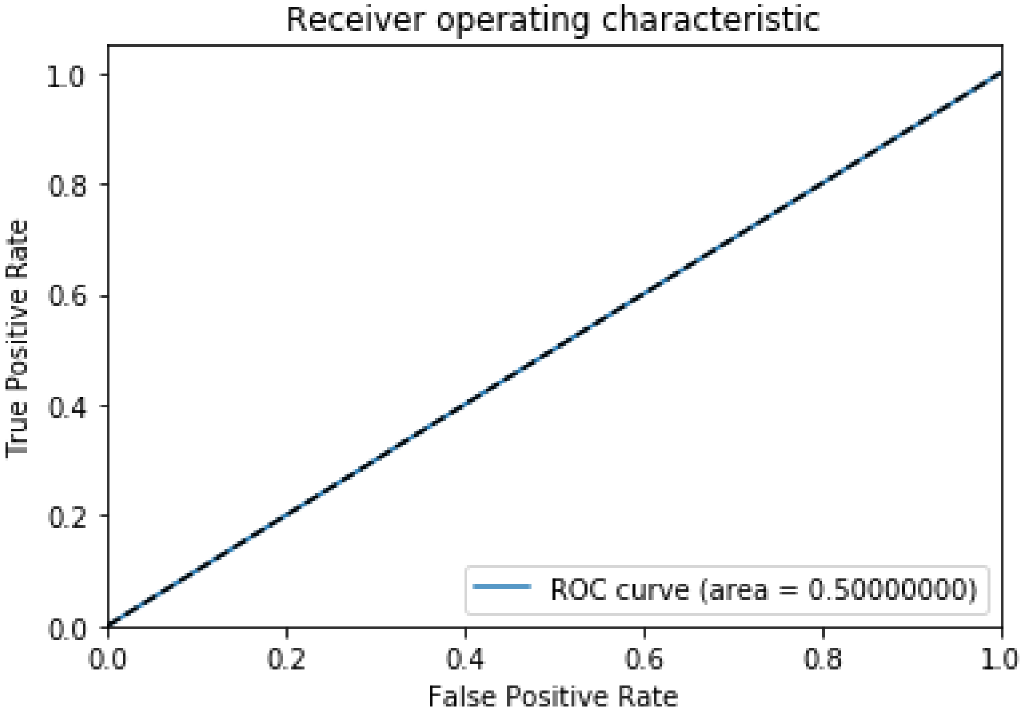

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

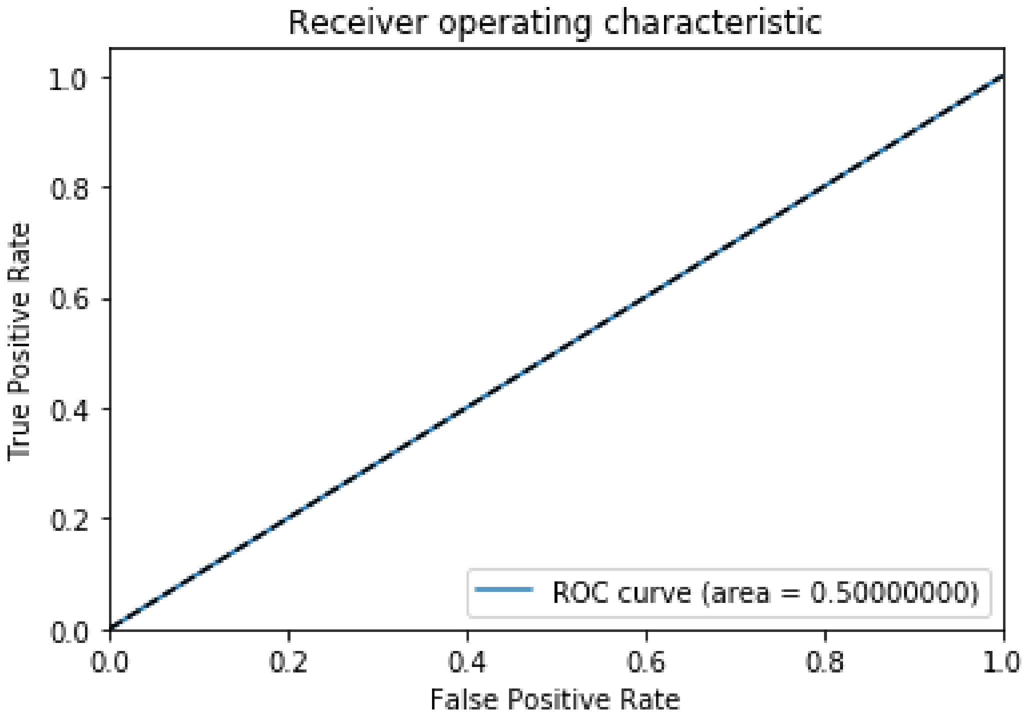

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

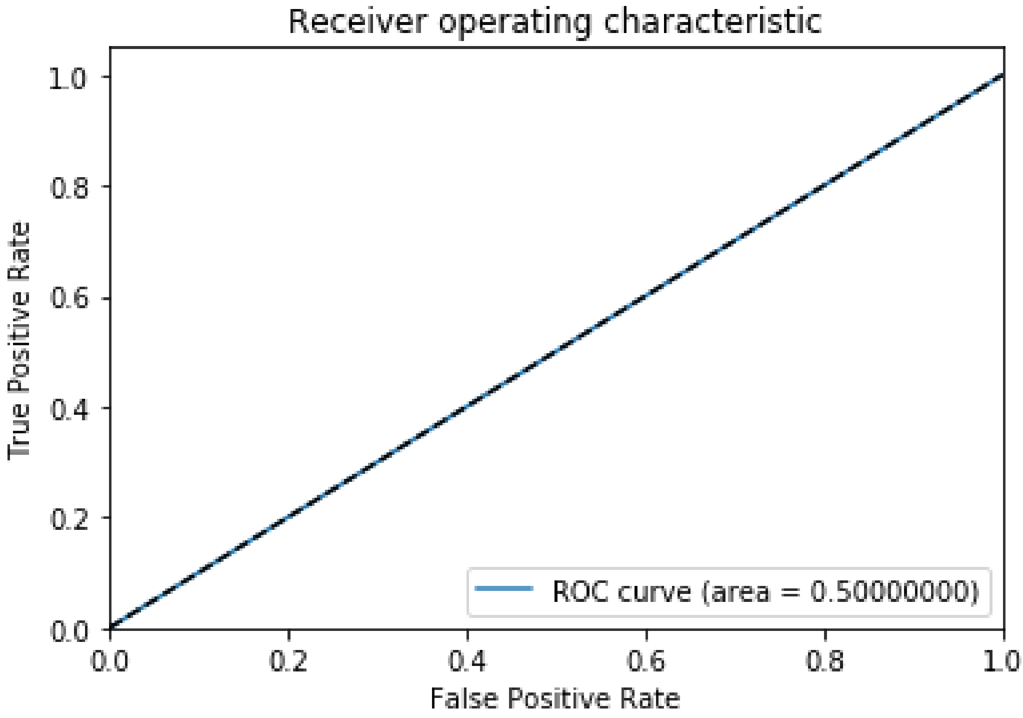

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

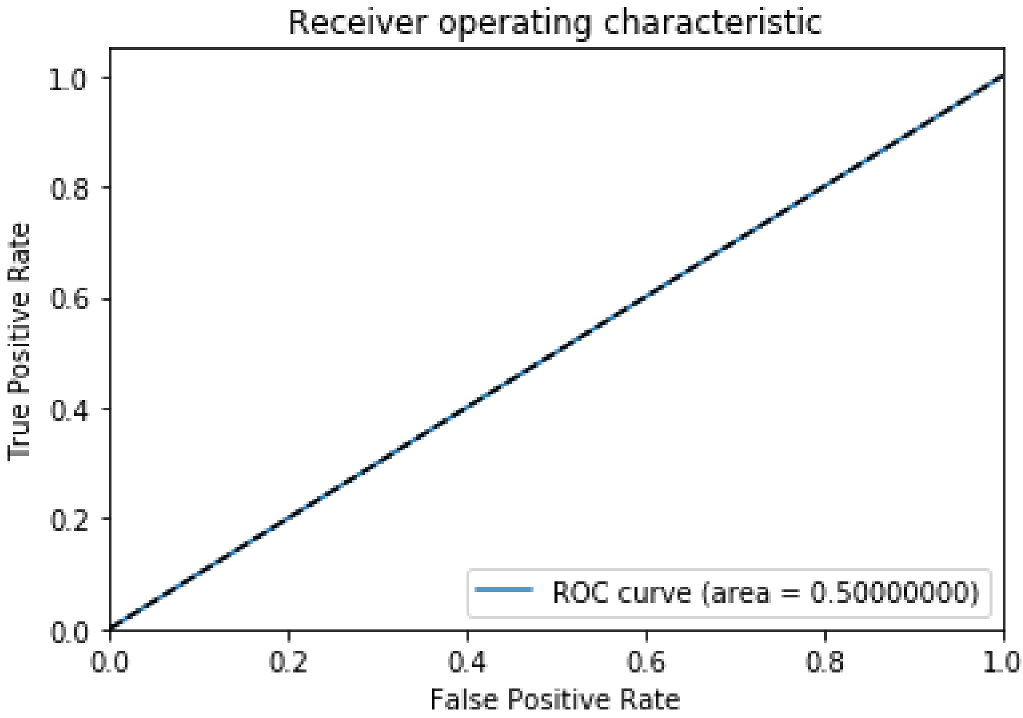

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

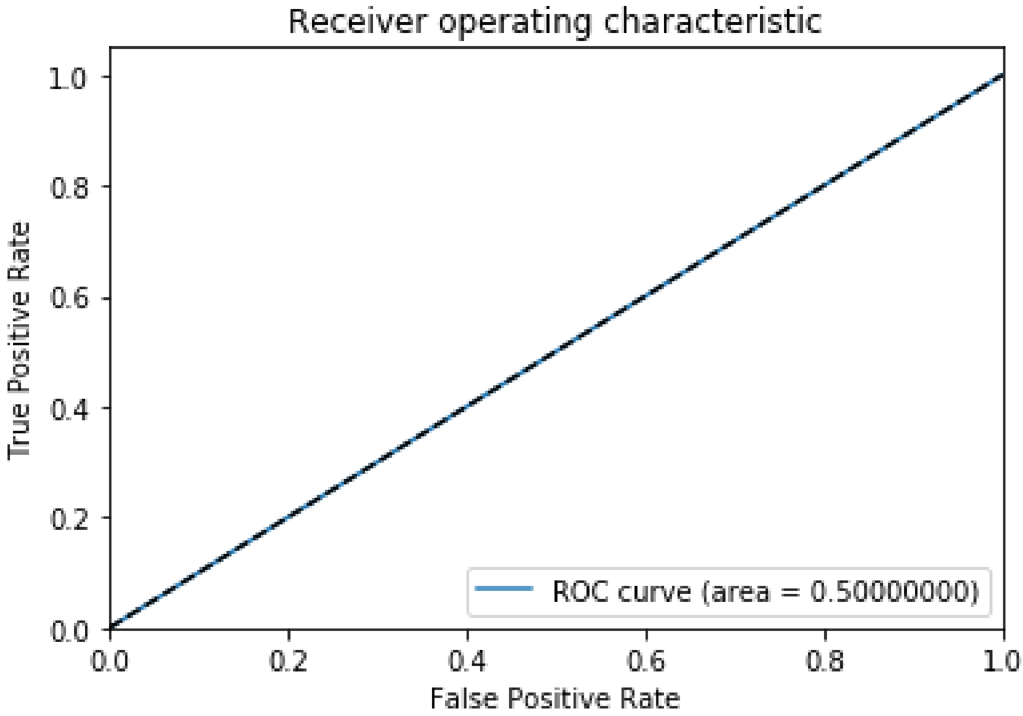

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)

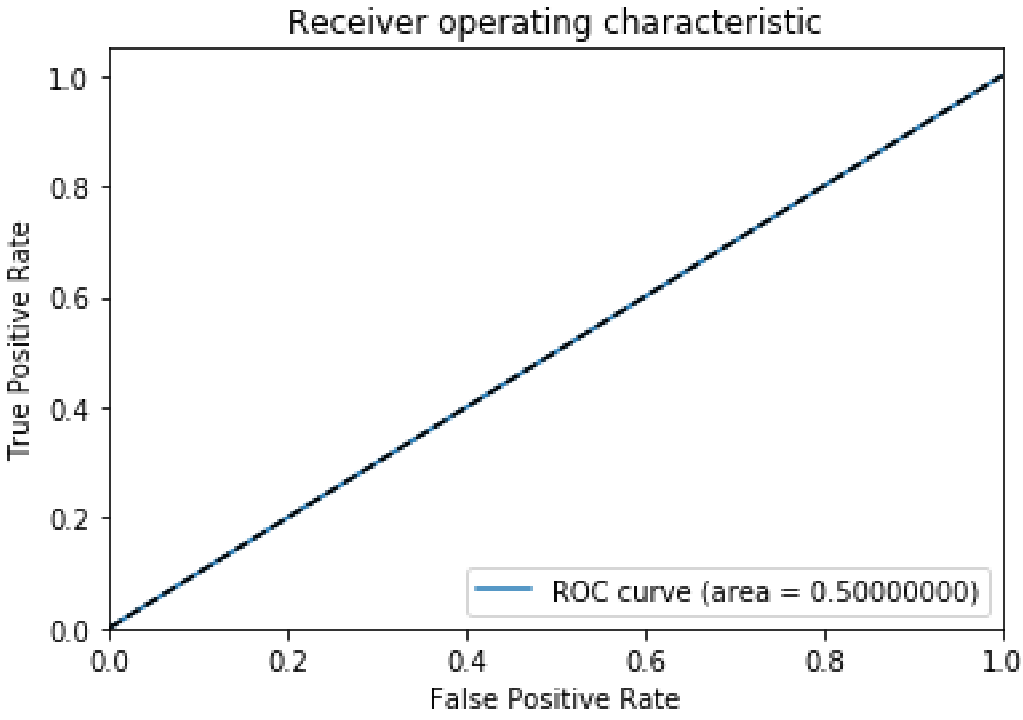
Train using train_test_split

```
[40]: X_train_DT, X_test_DT, y_train_DT, y_test_DT = X_train, X_test, y_train, y_test
      model.fit(X_train_DT,y_train_DT)
```

```
[40]: DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                             max_features='auto', max_leaf_nodes=None,
                             min_impurity_decrease=0.1834347898661638,
                             min_impurity_split=None, min_samples_leaf=4,
                             min_samples_split=2, min_weight_fraction_leaf=0,
                             presort=False, random_state=42, splitter='best')
```

Test the classifier

```
[41]: y_pred = model.predict(X_test_DT)
      plot_roc_auc(y_test_DT,y_pred)
```



Evaluate the results

```
[42]: print(np.array(accuracy_DT_KF).mean()) #k fold accuracy
```

```
0.6102803738317756
```

```
[43]: print(np.array(roc_auc_DT_KF).mean()) #k fold roc auc
```

```
0.5
```

```
[44]: print(np.array(accuracy_DT_SKF).mean()) #stratified k fold accuracy
```

```
0.6102862516898842
```

```
[45]: print(np.array(roc_auc_DT_SKF).mean()) #stratified k fold roc auc
```

```
0.5
```

```
[46]: print(accuracy_score(y_pred,y_test_DT)) #train test split
```

```
0.6074766355140186
```

```
[47]: print(np.array(cross_val_score(model,X_DT_CV,y_DT_CV,cv=10)).mean()) #cross val
```

```
0.6102862516898842
```

Show other scores from train_test_split()

```
[48]: print_scores(model.__class__.__name__, y_test_DT, y_pred)
```

```
Model: DecisionTreeClassifier
========================================================
*Accuracy score: 0.6074766355140186
--------------------------------------------------------
Classification report:
              precision    recall  f1-score   support

           0       0.61      1.00      0.76       130
           1       0.00      0.00      0.00        84

    accuracy                           0.61       214
   macro avg       0.30      0.50      0.38       214
weighted avg       0.37      0.61      0.46       214

--------------------------------------------------------
Confusion matrix:
[[130   0]
 [ 84   0]]
--------------------------------------------------------
Precision score: 0.0
--------------------------------------------------------
Recall score: 0.0
--------------------------------------------------------
F1 score: 0.0
--------------------------------------------------------
Log loss score: 13.557276715759333
--------------------------------------------------------
ROC-AUC score: 0.5
--------------------------------------------------------
```

```
Sensitivity score: 1.0
--------------------------------------------------------
Specificity score: 0.0
```

```
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\metrics\classification.py:1437: UndefinedMetricWarning:
Precision and F-score are ill-defined and being set to 0.0 in labels with no
predicted samples.
  'precision', 'predicted', average, warn_for)
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\metrics\classification.py:1437: UndefinedMetricWarning:
Precision is ill-defined and being set to 0.0 due to no predicted samples.
  'precision', 'predicted', average, warn_for)
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\metrics\classification.py:1437: UndefinedMetricWarning: F-score
is ill-defined and being set to 0.0 due to no predicted samples.
  'precision', 'predicted', average, warn_for)
```

1.0.2 2. Random Forest

Determine best parameters for a Random Forest classifier

[49]:

```python
n_estimators_range=list(range(10,20))
criterion_options=["gini","entropy"]
max_features_options=["auto","sqrt","log2"]
max_depth_range=list(range(1,5))
min_samples_split_range=list(range(2,5))
min_samples_leaf_range=list(range(1,5))
min_weight_fraction_leaf_range=[0,0.5]
max_leaf_nodes_range=list(range(2,5))
min_impurity_decrease_range=uniform(0,1)
bootstrap_options=[True,False]
random_state_range=[42]

param_grid = dict(
                    n_estimators=n_estimators_range,
                    criterion=criterion_options,
                    max_features=max_features_options,
                    max_depth=max_depth_range,
                    min_samples_split=min_samples_split_range,
                    min_samples_leaf=min_samples_leaf_range,
                    min_weight_fraction_leaf=min_weight_fraction_leaf_range,
                    max_leaf_nodes=max_leaf_nodes_range,
                    random_state=random_state_range,
                    min_impurity_decrease=min_impurity_decrease_range,
                    bootstrap=bootstrap_options
                    )

cross_val = RandomForestClassifier()
```

```
grid = RandomizedSearchCV(cross_val, param_grid, random_state=42, n_iter=45,␣
 ↪cv=10, scoring='accuracy', verbose=0)
%time grid.fit(X_GSCV_RF,y_GSCV_RF)

print (grid.best_score_)
print (grid.best_params_)
print (grid.best_estimator_)
```

```
Wall time: 21.1 s
0.8009345794392523
{'bootstrap': True, 'criterion': 'gini', 'max_depth': 2, 'max_features': 'auto',
'max_leaf_nodes': 2, 'min_impurity_decrease': 0.06489224710898156,
'min_samples_leaf': 2, 'min_samples_split': 3, 'min_weight_fraction_leaf': 0,
'n_estimators': 11, 'random_state': 42}
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                       max_depth=2, max_features='auto', max_leaf_nodes=2,
                       min_impurity_decrease=0.06489224710898156,
                       min_impurity_split=None, min_samples_leaf=2,
                       min_samples_split=3, min_weight_fraction_leaf=0,
                       n_estimators=11, n_jobs=None, oob_score=False,
                       random_state=42, verbose=0, warm_start=False)
```

```
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\model_selection\_search.py:813: DeprecationWarning: The default
of the `iid` parameter will change from True to False in version 0.22 and will
be removed in 0.24. This will change numeric results when test-set sizes are
unequal.
  DeprecationWarning)
```

Create a Random Forest classifier

[50]:
```
model=RandomForestClassifier(bootstrap=True, class_weight=None,␣
 ↪criterion='gini',
                       max_depth=2, max_features='auto', max_leaf_nodes=2,
                       min_impurity_decrease=0.06489224710898156,
                       min_impurity_split=None, min_samples_leaf=2,
                       min_samples_split=3, min_weight_fraction_leaf=0,
                       n_estimators=11, n_jobs=None, oob_score=False,
                       random_state=42, verbose=0, warm_start=False)
```

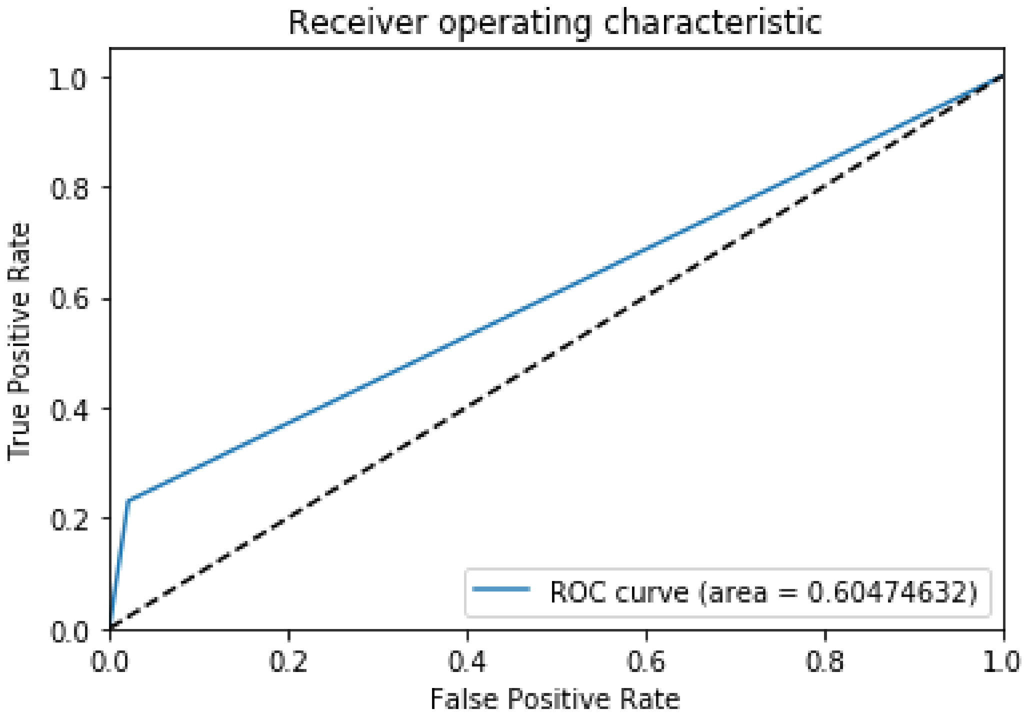
Train using K Fold

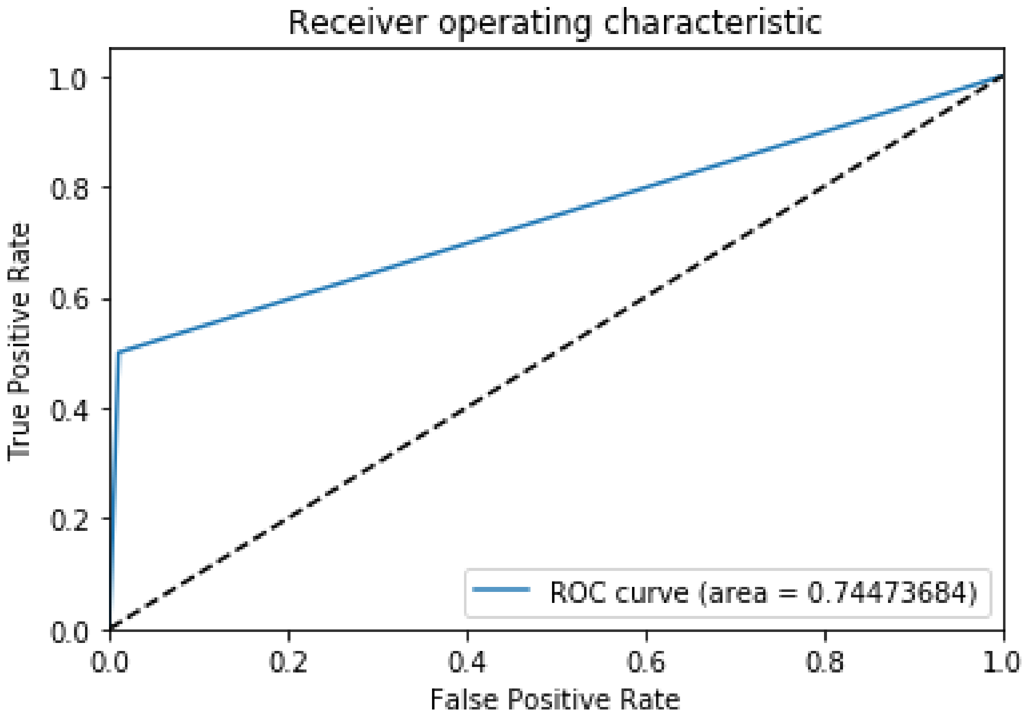
[51]:
```
accuracy_RF_KF=[]
roc_auc_RF_KF=[]
```

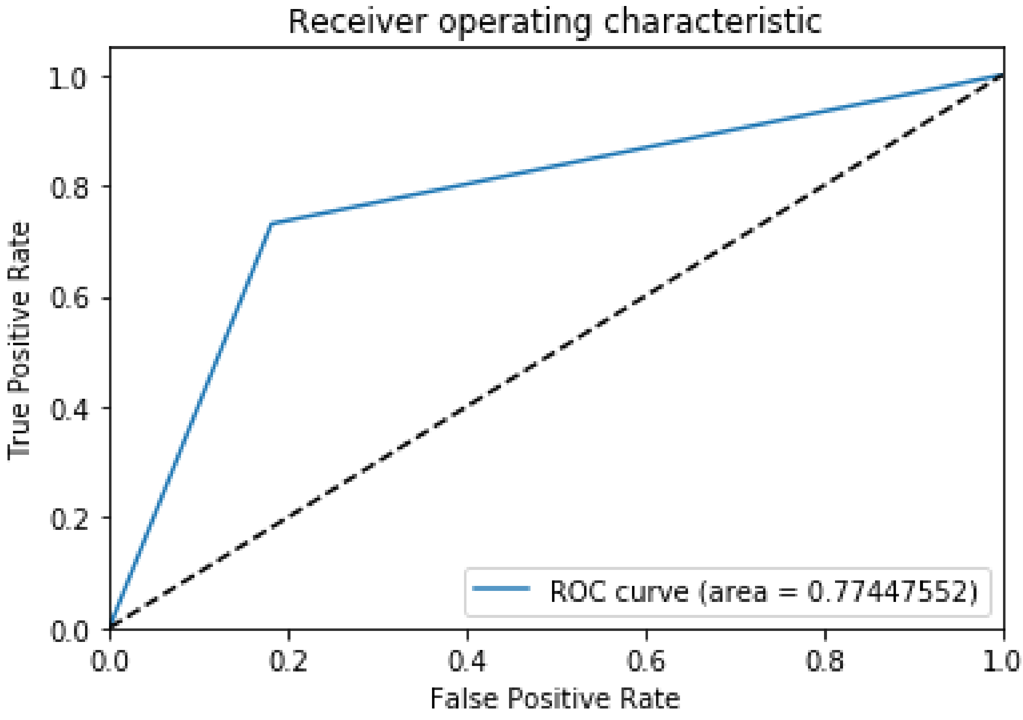
[52]:
```
kf_RF = KFold(n_splits=10,random_state=42)
```

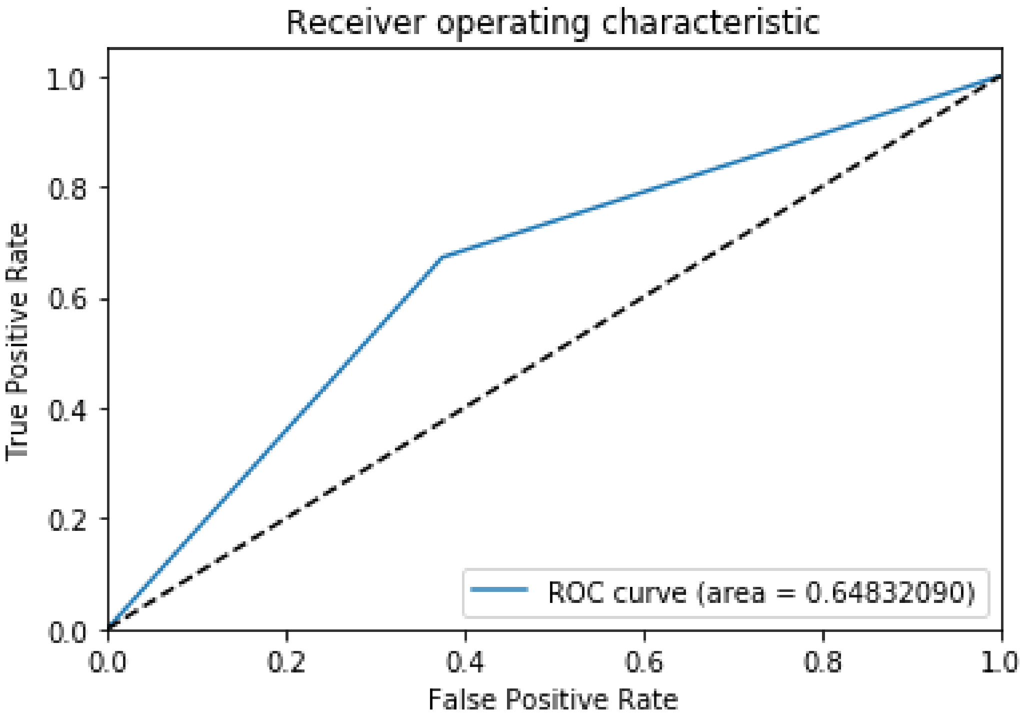
[53]:

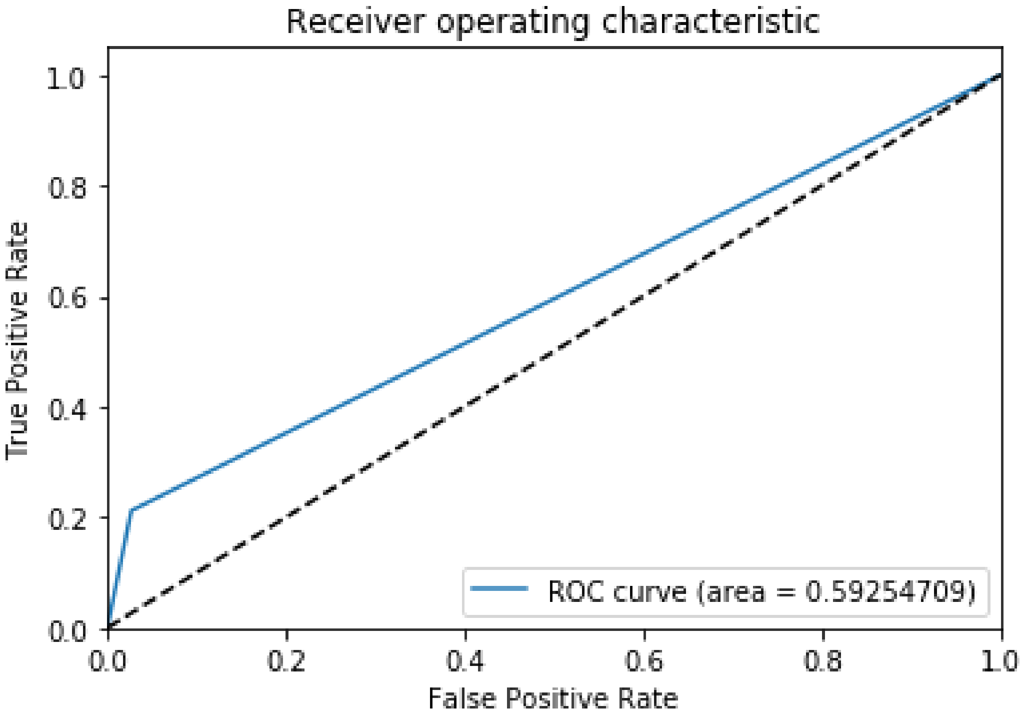
```
for train_index,test_index in kf_RF.split(X_RF_KF,y_RF_KF):
    X_train_RF_KF,X_test_RF_KF,y_train_RF_KF,y_test_RF_KF = X_RF_KF.
 ↪iloc[train_index],X_RF_KF.iloc[test_index],y_RF_KF.iloc[train_index],y_RF_KF.
 ↪iloc[test_index]

    model.fit(X_train_RF_KF,y_train_RF_KF)
    y_pred = model.predict(X_test_RF_KF)
    score=accuracy_score(y_pred,y_test_RF_KF)
    accuracy_RF_KF.append(score)
    roc_auc_RF_KF.append(roc_auc_score(y_test_RF_KF,y_pred))
    plot_roc_auc(y_test_RF_KF,y_pred)
```

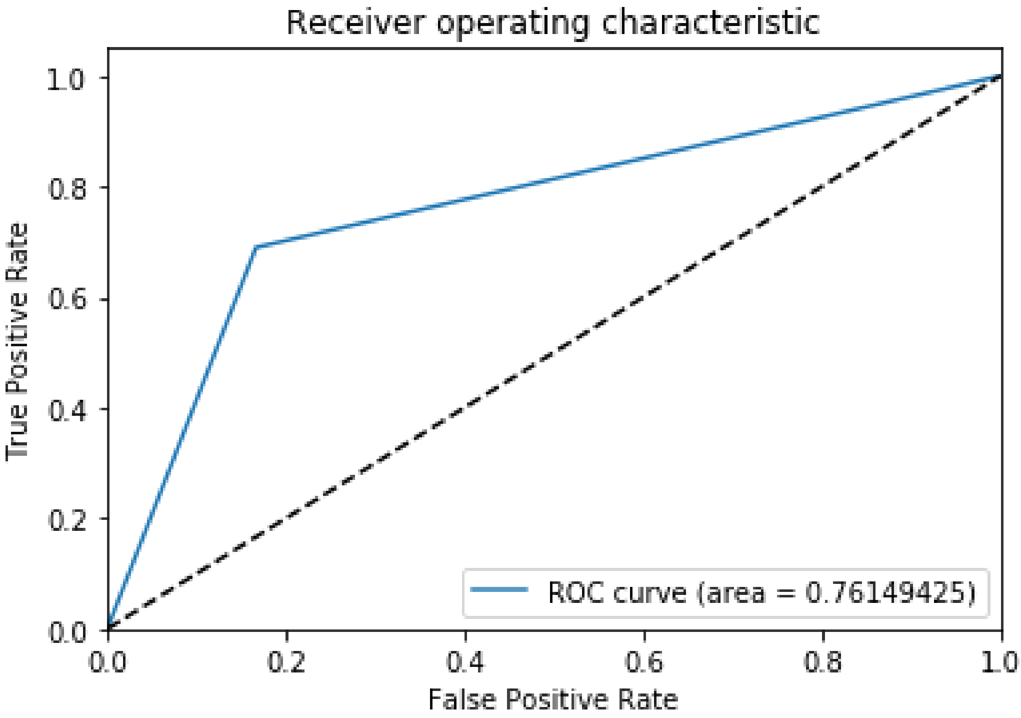


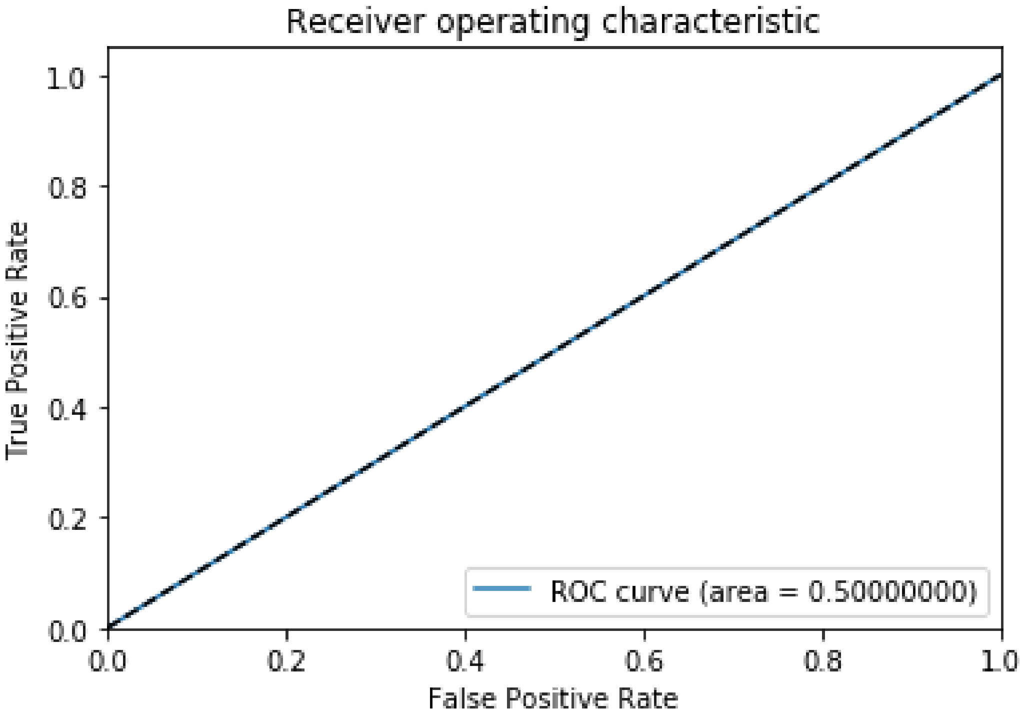

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.74473684)

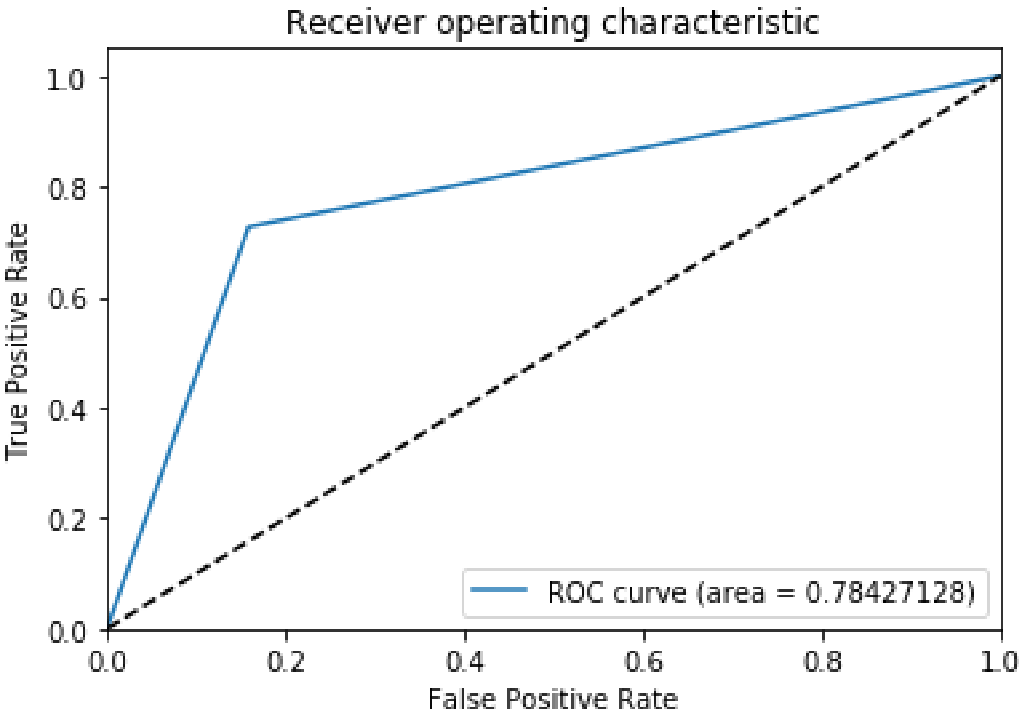

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.77447552)

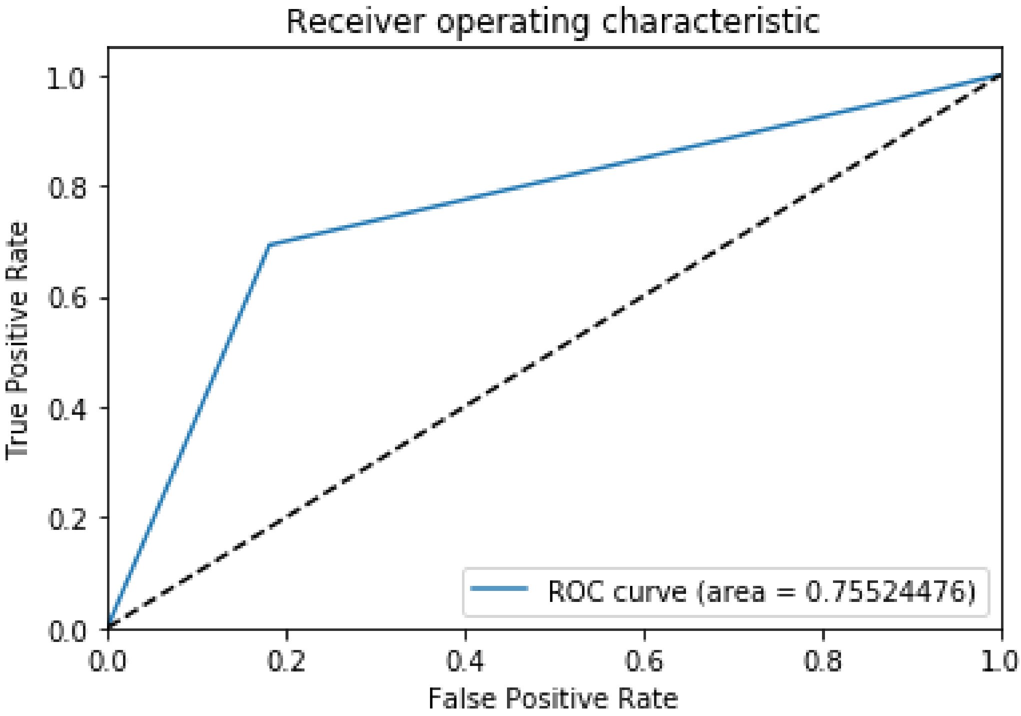

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.64832090)

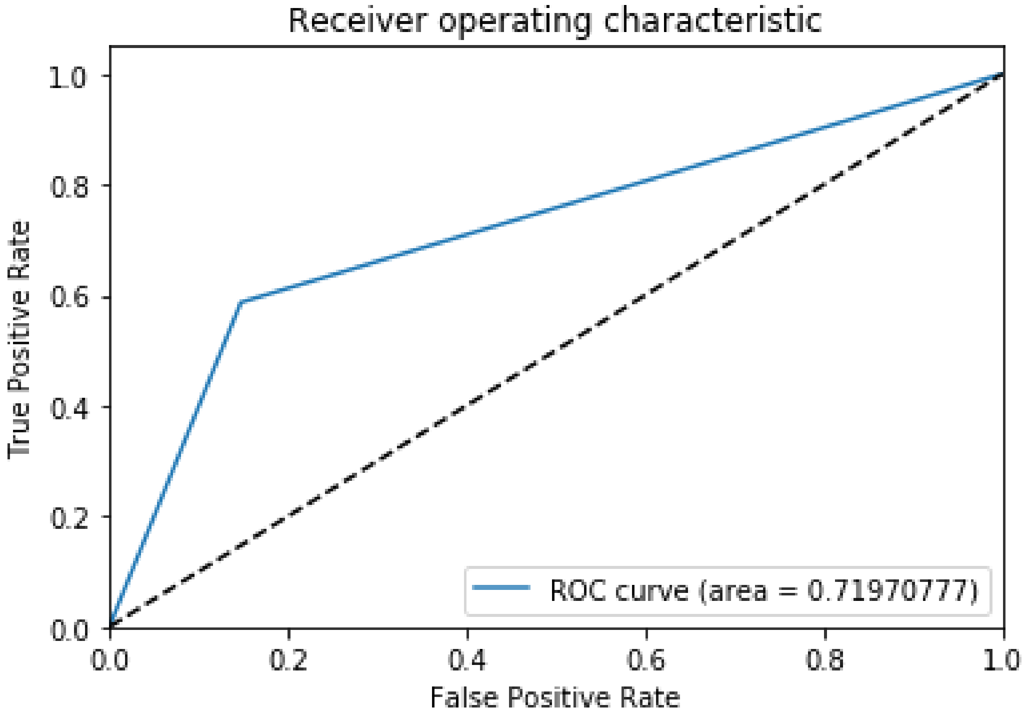

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.59254709)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.76149425)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.50000000)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.78427128)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.75524476)

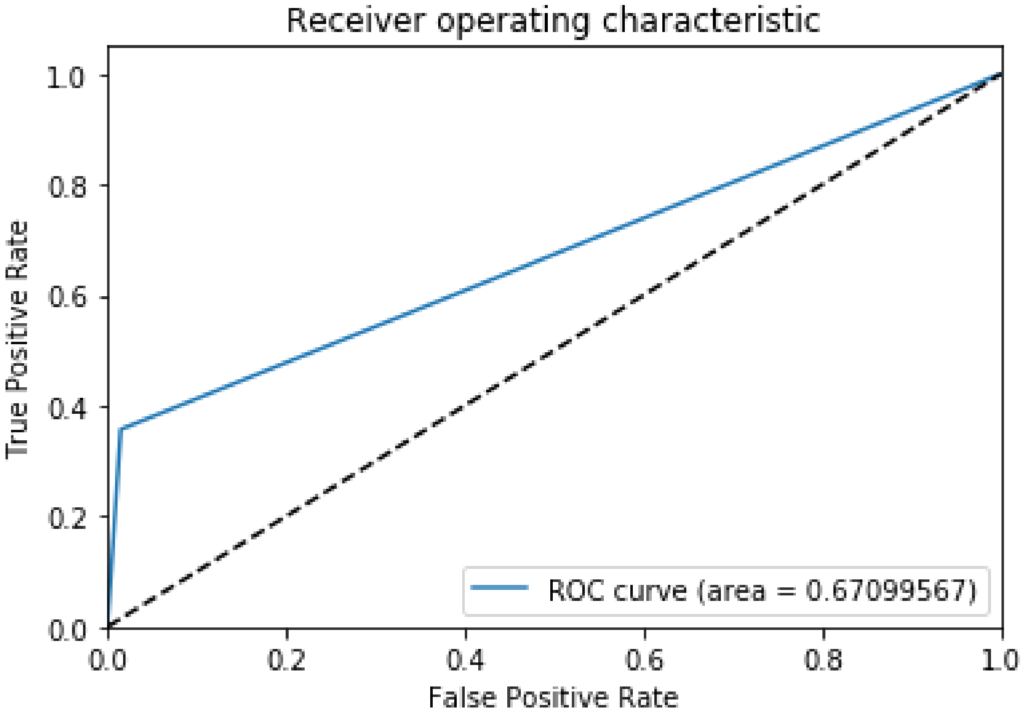


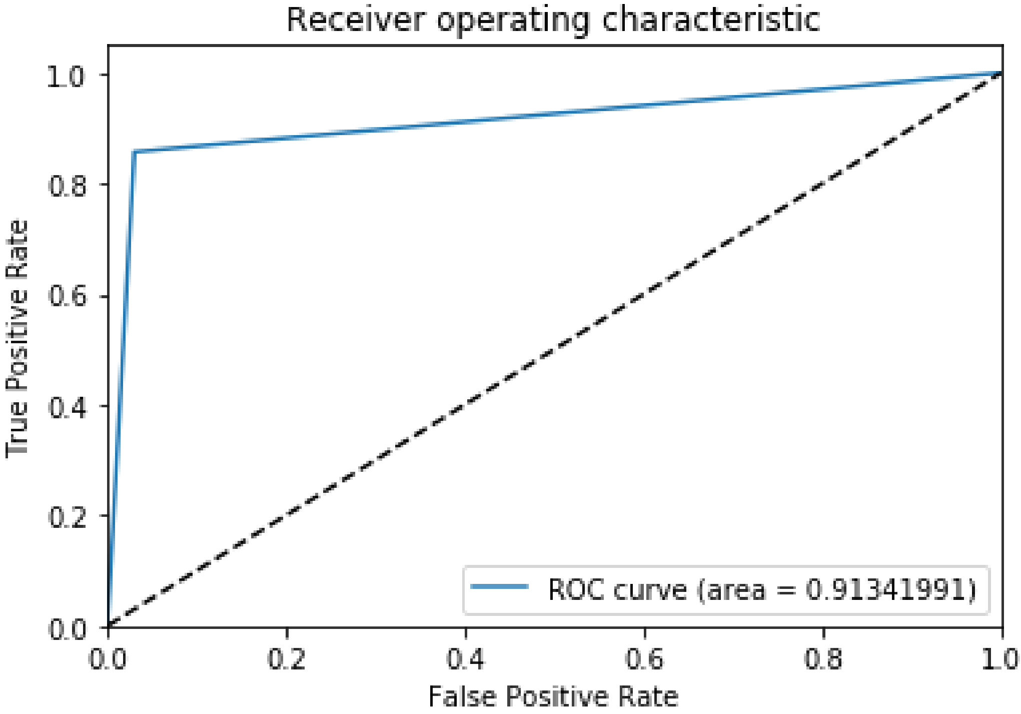
Train using Stratified K Fold

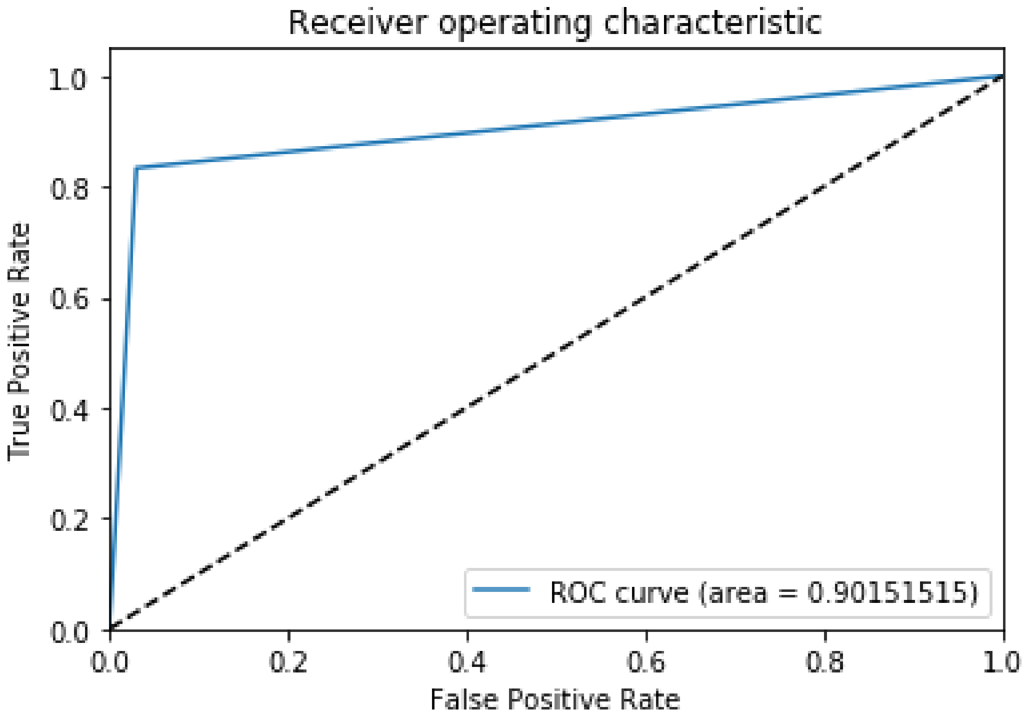
```
[54]: accuracy_RF_SKF=[]
      roc_auc_RF_SKF=[]
```

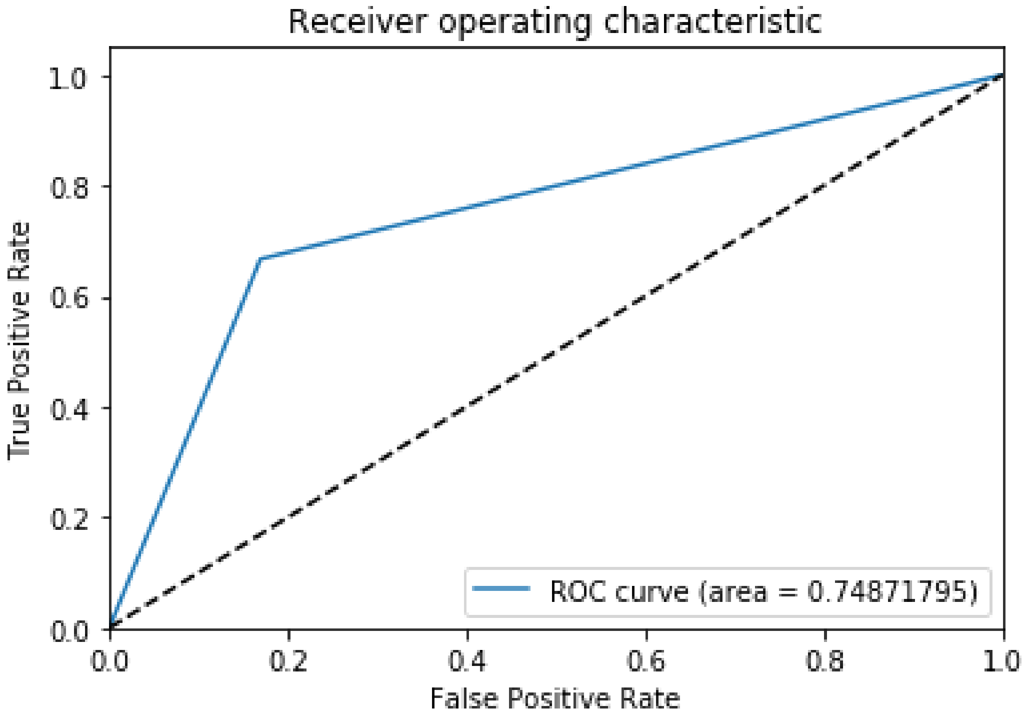
```
[55]: skf_RF = StratifiedKFold(n_splits=10,random_state=42)
```

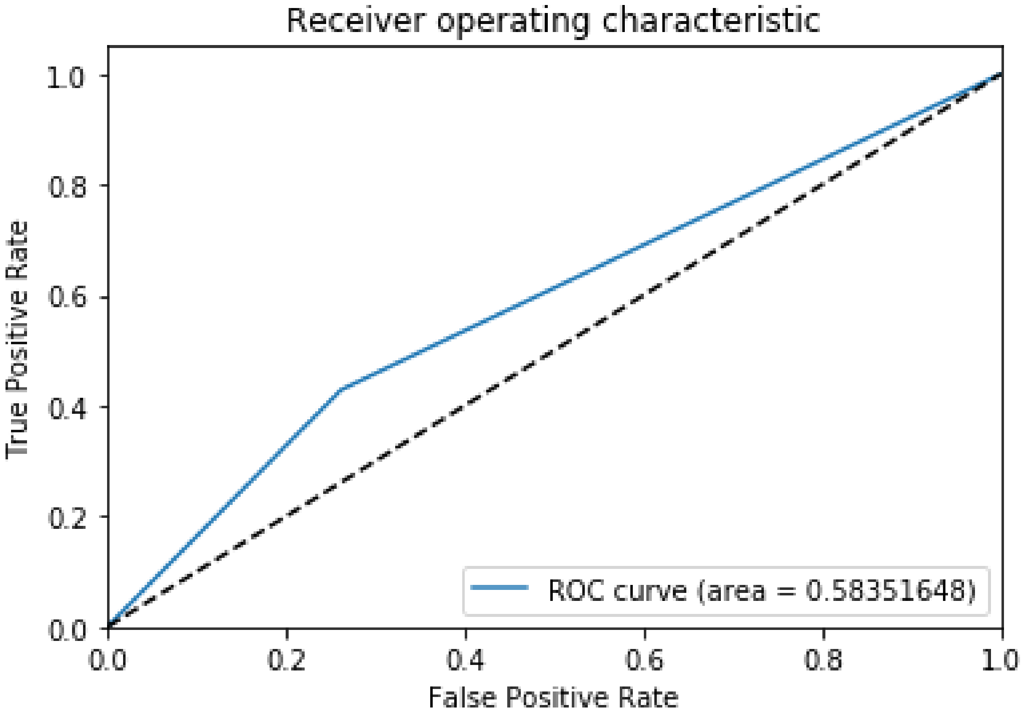
```
[56]: for train_index,test_index in skf_RF.split(X_RF_SKF,y_RF_SKF):
          X_train_RF_SKF,X_test_RF_SKF,y_train_RF_SKF,y_test_RF_SKF = X_RF_SKF.
       ↪iloc[train_index],X_RF_SKF.iloc[test_index],y_RF_SKF.
       ↪iloc[train_index],y_RF_SKF.iloc[test_index]

          model.fit(X_train_RF_SKF,y_train_RF_SKF)
          y_pred = model.predict(X_test_RF_SKF)
          score=accuracy_score(y_pred,y_test_RF_SKF)
          accuracy_RF_SKF.append(score)
          roc_auc_RF_SKF.append(roc_auc_score(y_test_RF_SKF,y_pred))
          plot_roc_auc(y_test_RF_SKF,y_pred)
```

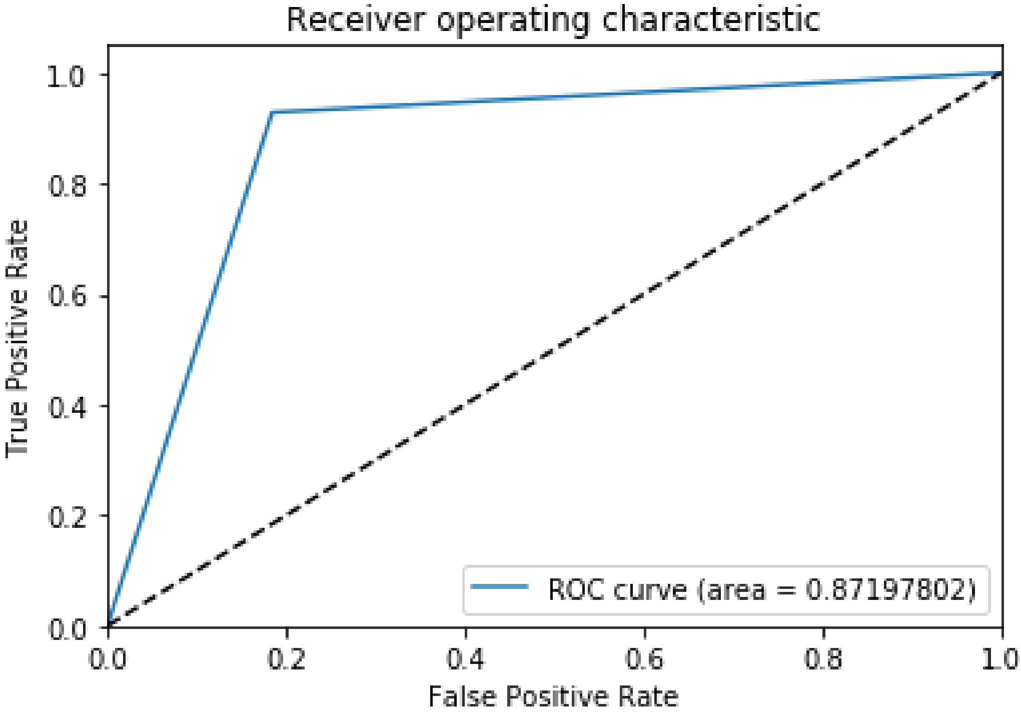

Receiver operating characteristic
True Positive Rate
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
ROC curve (area = 0.67099567)

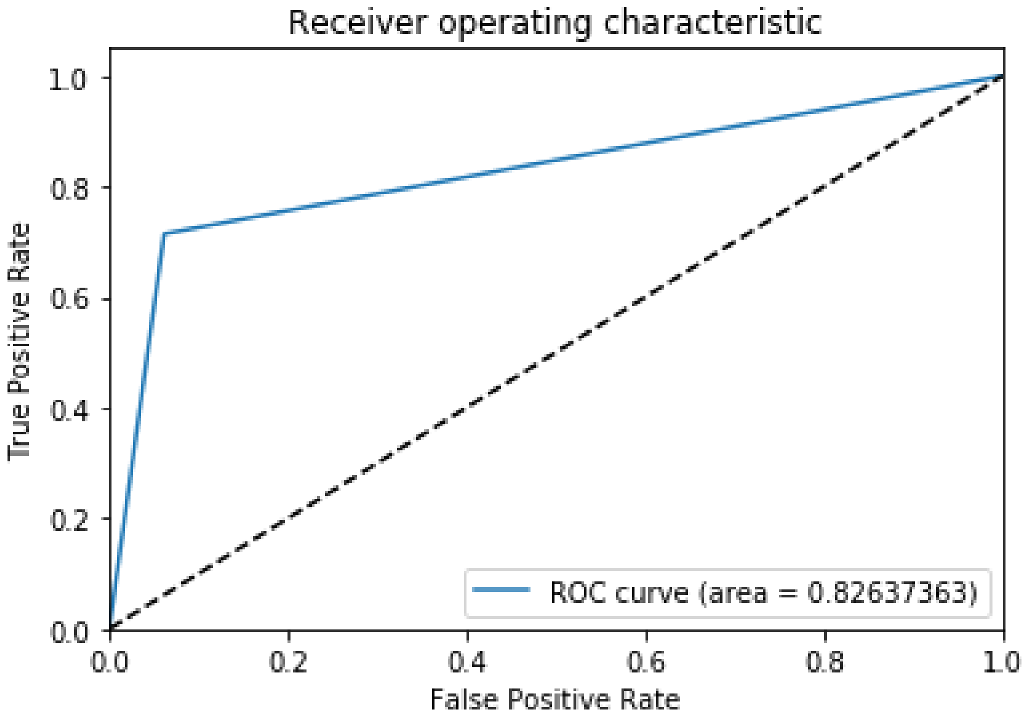

Receiver operating characteristic
True Positive Rate
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
ROC curve (area = 0.91341991)

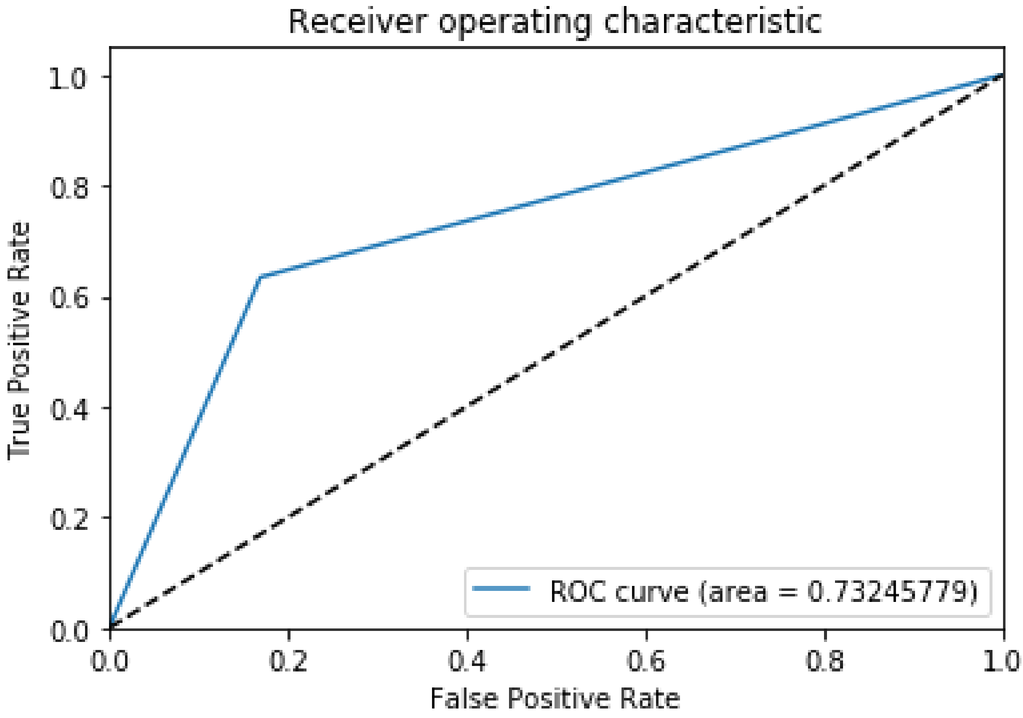

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.90151515)

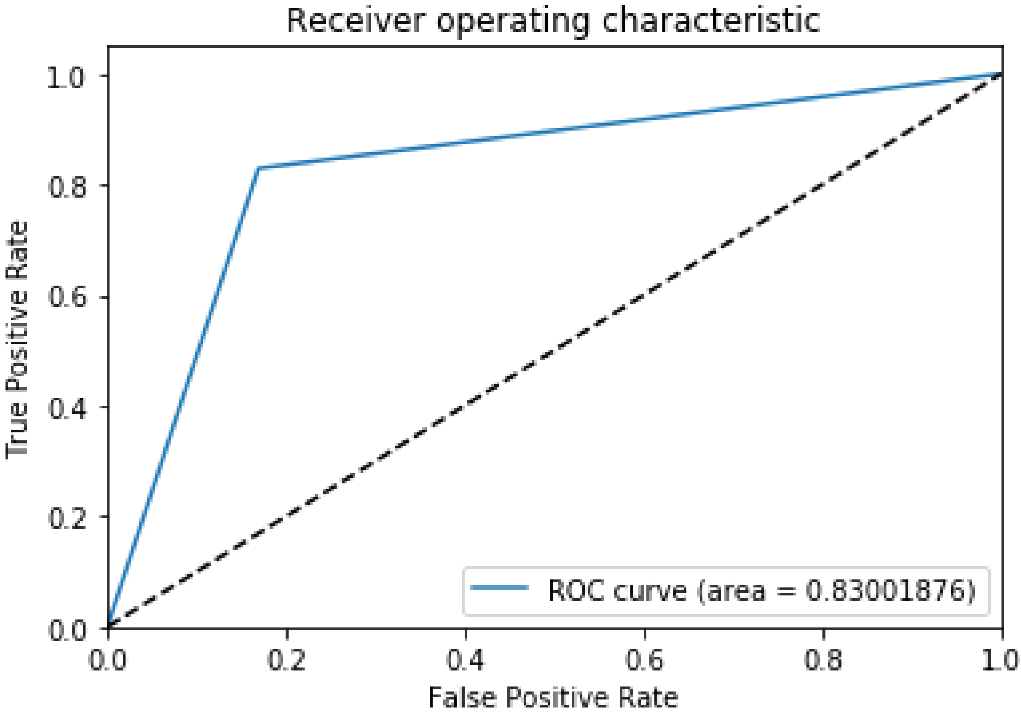

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.74871795)

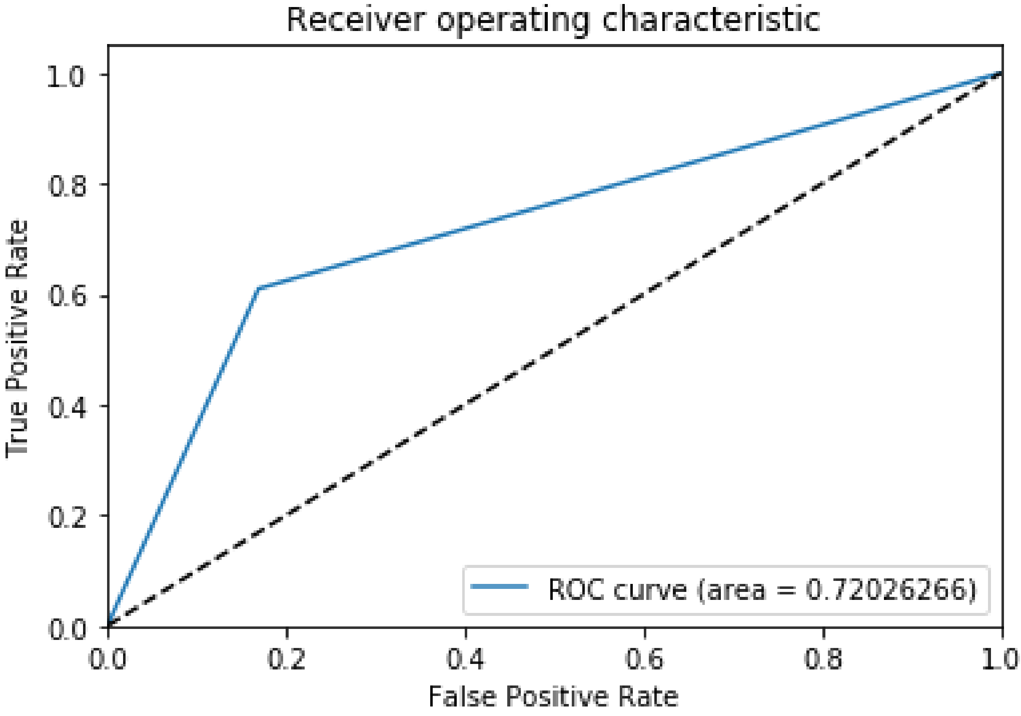

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.58351648)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.87197802)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.82637363)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.73245779)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.83001876)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.72026266)

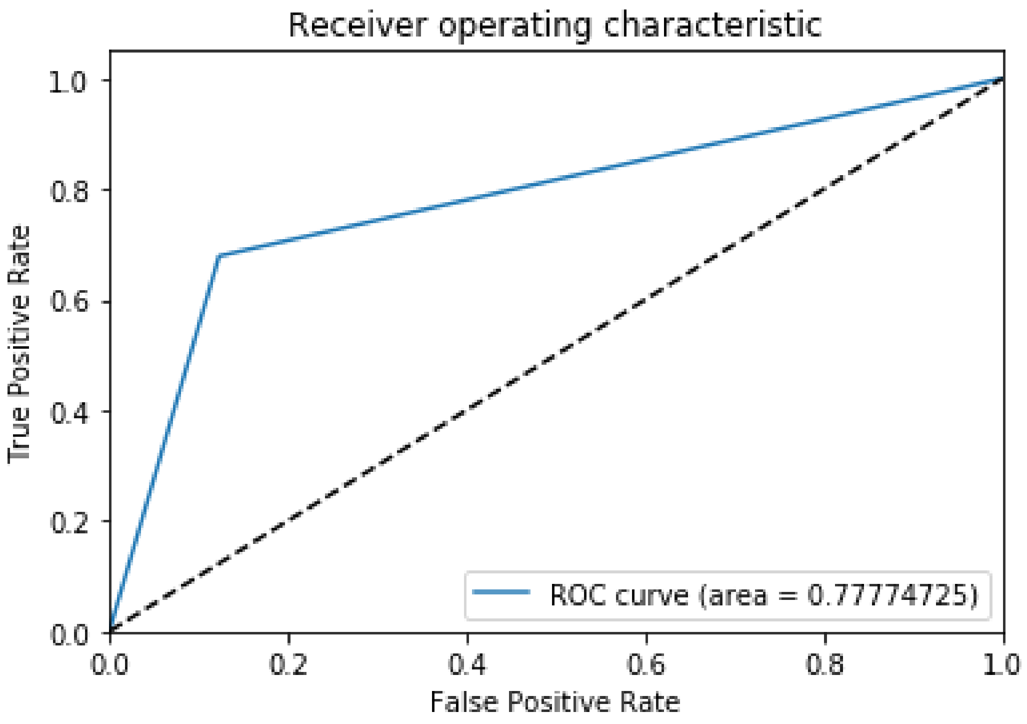
Train using train_test_split

```
[57]: X_train_RF, X_test_RF, y_train_RF, y_test_RF = X_train, X_test, y_train, y_test
      model.fit(X_train_RF,y_train_RF)
```

```
[57]: RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                             max_depth=2, max_features='auto', max_leaf_nodes=2,
                             min_impurity_decrease=0.06489224710898156,
                             min_impurity_split=None, min_samples_leaf=2,
                             min_samples_split=3, min_weight_fraction_leaf=0,
                             n_estimators=11, n_jobs=None, oob_score=False,
                             random_state=42, verbose=0, warm_start=False)
```

Test the classifier

```
[58]: y_pred = model.predict(X_test_RF)
      plot_roc_auc(y_test_RF,y_pred)
```



Evaluate the results

```
[59]: print(np.array(accuracy_RF_KF).mean()) #k fold accuracy
```

```
0.7429906542056074
```

```
[60]: print(np.array(roc_auc_RF_KF).mean()) #k fold roc auc
```

```
0.6885544733618432
```

```
[61]: print(np.array(accuracy_RF_SKF).mean()) #stratified k fold accuracy
```

```
0.800697995650385
```

```
[62]: print(np.array(roc_auc_RF_SKF).mean()) #stratified k fold roc auc
```

```
0.7799256028524322
```

```
[63]: print(accuracy_score(y_pred,y_test_RF)) #train test split
```

```
0.7990654205607477
```

```
[64]: print(np.array(cross_val_score(model,X_RF_CV,y_RF_CV,cv=10)).mean()) #cross val
```

```
0.800697995650385
```

Show other scores from train_test_split()

```
[65]: print_scores(model.__class__.__name__, y_test_RF, y_pred)
```

```
Model: RandomForestClassifier
========================================================
*Accuracy score: 0.7990654205607477
--------------------------------------------------------
Classification report:
              precision    recall  f1-score   support

           0       0.81      0.88      0.84       130
           1       0.78      0.68      0.73        84

    accuracy                           0.80       214
   macro avg       0.79      0.78      0.78       214
weighted avg       0.80      0.80      0.80       214

--------------------------------------------------------
Confusion matrix:
[[114  16]
 [ 27  57]]
--------------------------------------------------------
Precision score: 0.7808219178082192
--------------------------------------------------------
Recall score: 0.6785714285714286
--------------------------------------------------------
F1 score: 0.7261146496815287
--------------------------------------------------------
Log loss score: 6.940094292243188
--------------------------------------------------------
```

```
ROC-AUC score: 0.7777472527472528
--------------------------------------------------------
Sensitivity score: 0.8769230769230769
--------------------------------------------------------
Specificity score: 0.6785714285714286
```

1.0.3 3. Logistic Regression

Determine best parameters for a Logistic Regression classifier

[66]:

```
tol_range=uniform(0,1)
C_range=uniform(0,10)
fit_intercept_options=[True,False]
solver_options=["liblinear","saga","sag","lbfgs","newton-cg"]
max_iter_range=list(range(100,110))
random_state_range=[42]

param_grid = dict(
                    tol=tol_range,
                    C=C_range,
                    fit_intercept=fit_intercept_options,
                    solver=solver_options,
                    max_iter=max_iter_range,
                    random_state=random_state_range
                    )

cross_val = LogisticRegression()
grid = RandomizedSearchCV(cross_val, param_grid, random_state=42, n_iter=45,␣
 ↪cv=10, scoring='accuracy', verbose=0)
%time grid.fit(X_GSCV_LR,y_GSCV_LR)

print (grid.best_score_)
print (grid.best_params_)
print (grid.best_estimator_)
```

```
Wall time: 14.9 s
0.8336448598130841
{'C': 8.08397348116461, 'fit_intercept': True, 'max_iter': 109, 'random_state':
42, 'solver': 'newton-cg', 'tol': 0.230893825622149}
LogisticRegression(C=8.08397348116461, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, l1_ratio=None,
                   max_iter=109, multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=42, solver='newton-cg', tol=0.230893825622149,
                   verbose=0, warm_start=False)
```

```
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\model_selection\_search.py:813: DeprecationWarning: The default
of the `iid` parameter will change from True to False in version 0.22 and will
be removed in 0.24. This will change numeric results when test-set sizes are
```

```
unequal.
  DeprecationWarning)
```

Create a Logistic Regression classifier

[67]:

```
model=LogisticRegression(C=8.08397348116461, class_weight=None, dual=False,
                   fit_intercept=True, intercept_scaling=1, l1_ratio=None,
                   max_iter=109, multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=42, solver='newton-cg', tol=0.230893825622149,
                   verbose=0, warm_start=False)
```

Train using K Fold

[68]:

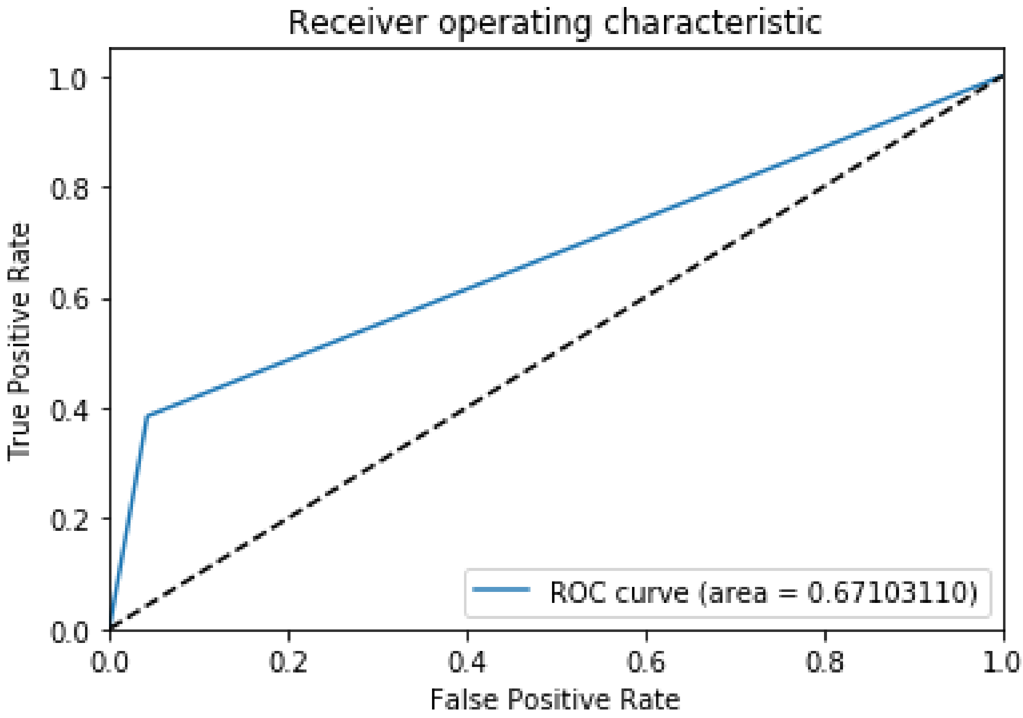
```
accuracy_LR_KF=[]
roc_auc_LR_KF=[]
```

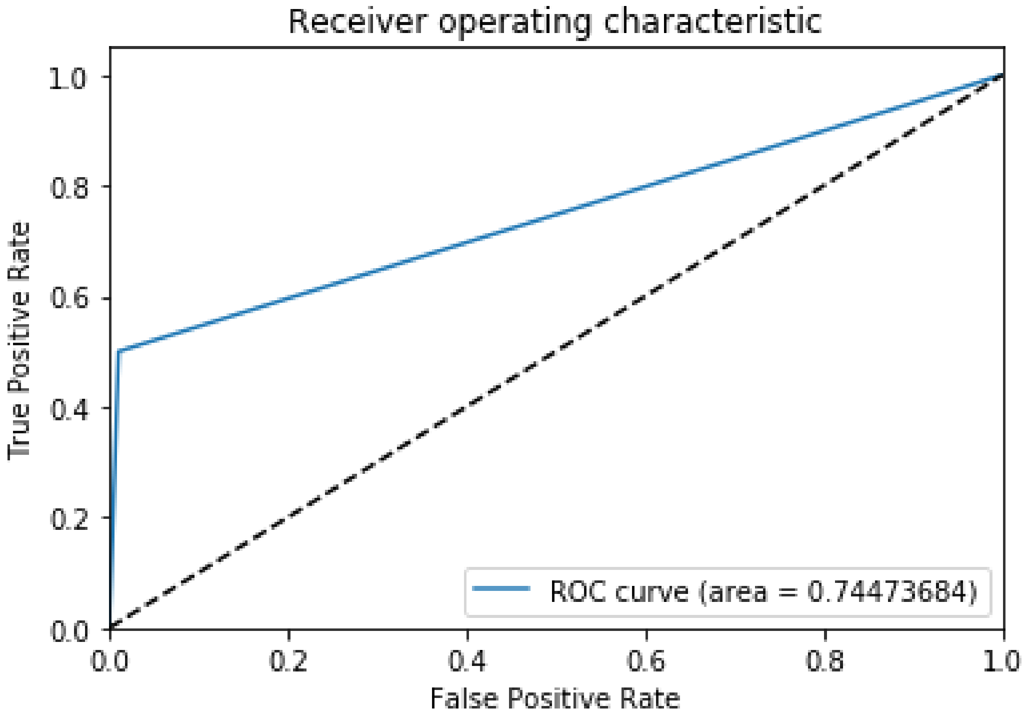
[69]:

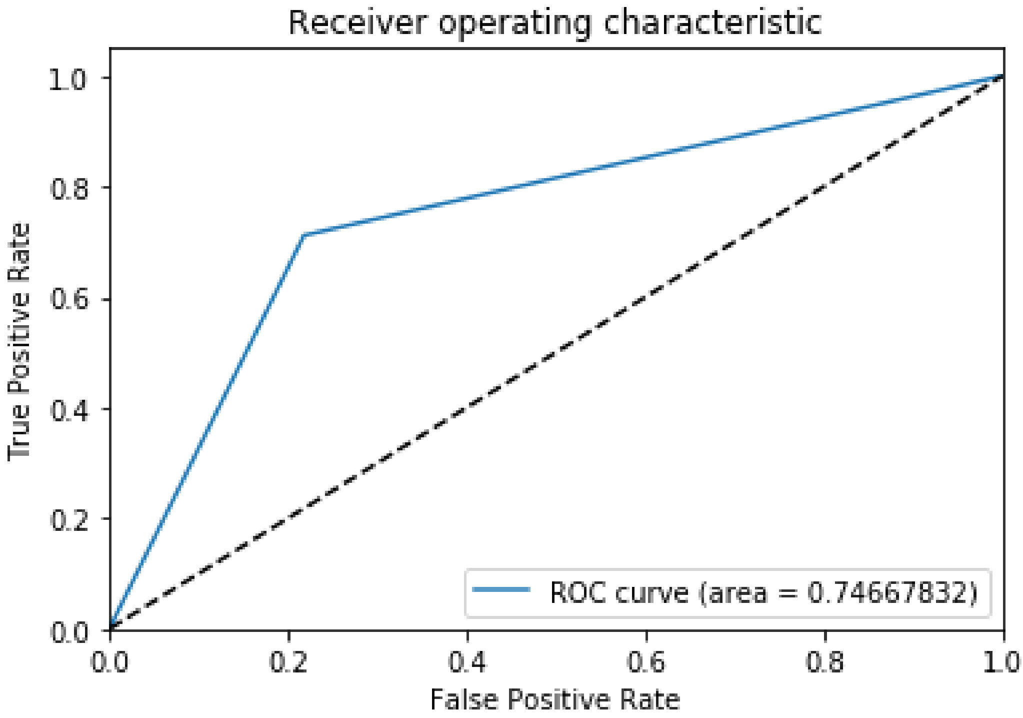
```
kf_LR = KFold(n_splits=10,random_state=42)
```

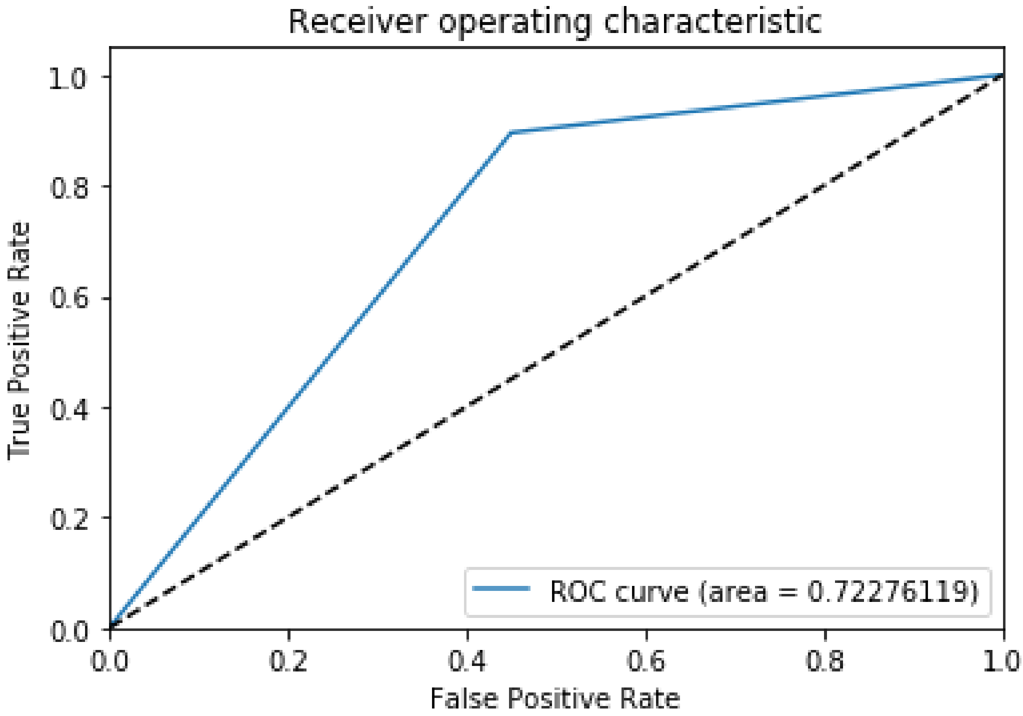
[70]:

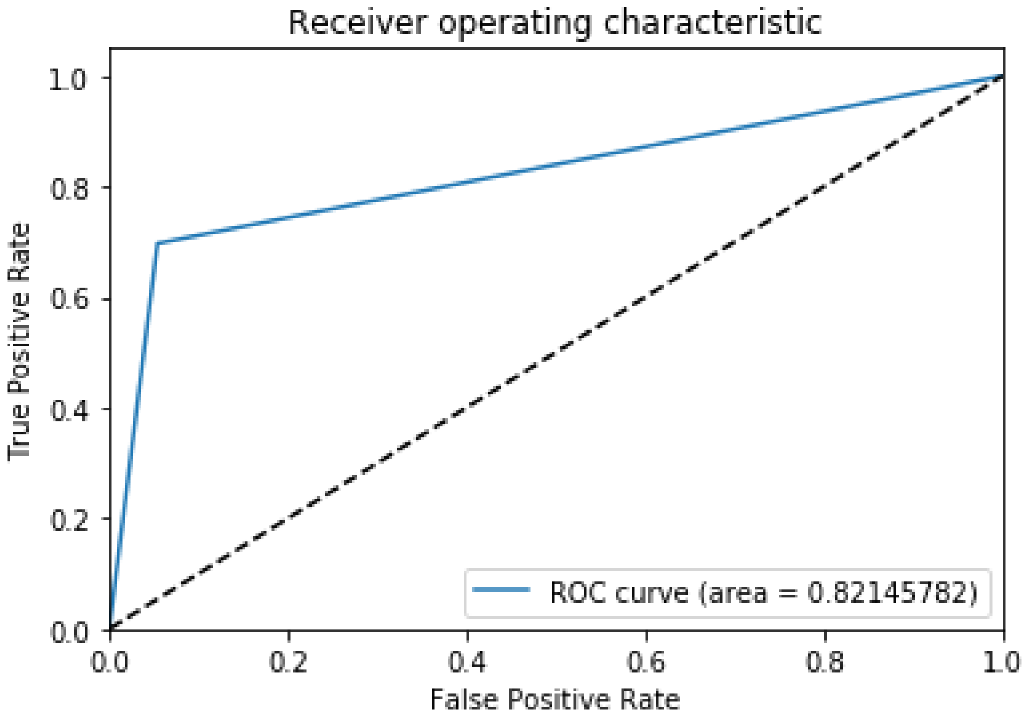
```
for train_index,test_index in kf_LR.split(X_LR_KF,y_LR_KF):
    X_train_LR_KF,X_test_LR_KF,y_train_LR_KF,y_test_LR_KF = X_LR_KF.
 ↪iloc[train_index],X_LR_KF.iloc[test_index],y_LR_KF.iloc[train_index],y_LR_KF.
 ↪iloc[test_index]

    model.fit(X_train_LR_KF,y_train_LR_KF)
    y_pred = model.predict(X_test_LR_KF)
    score=accuracy_score(y_pred,y_test_LR_KF)
    accuracy_LR_KF.append(score)
    roc_auc_LR_KF.append(roc_auc_score(y_test_LR_KF,y_pred))
    plot_roc_auc(y_test_LR_KF,y_pred)
```

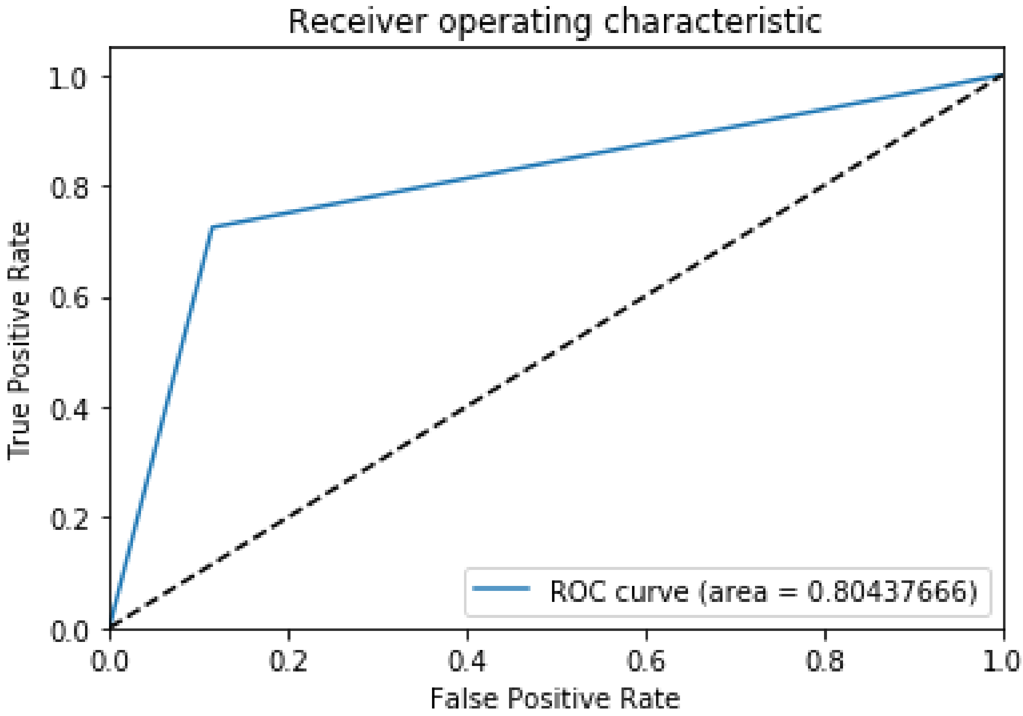

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.67103110)

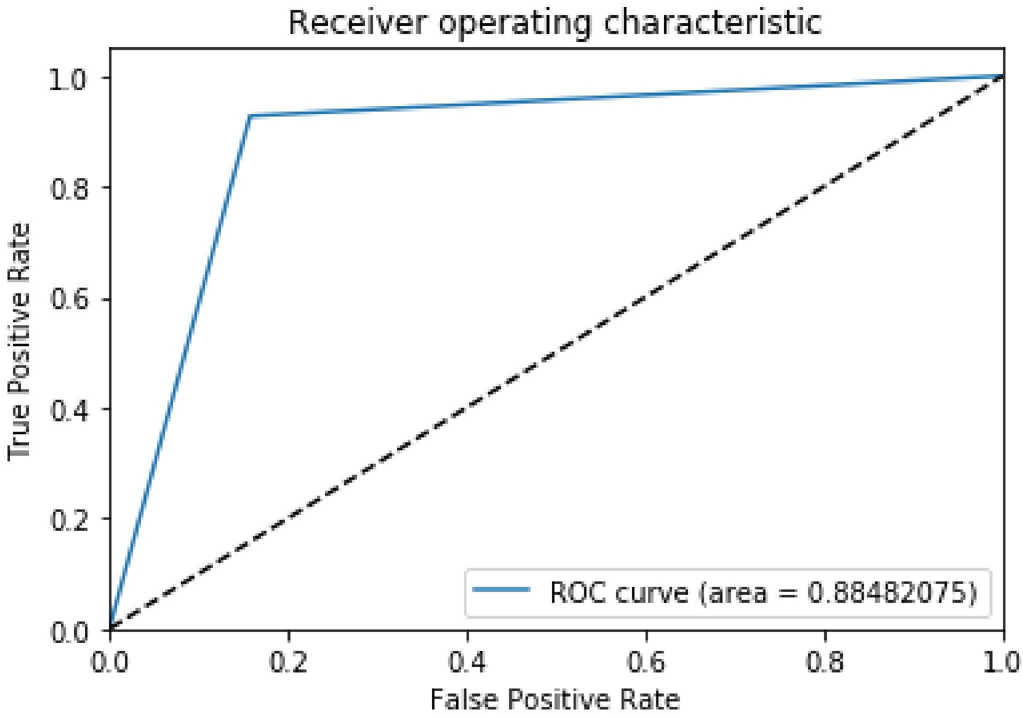

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.74473684)

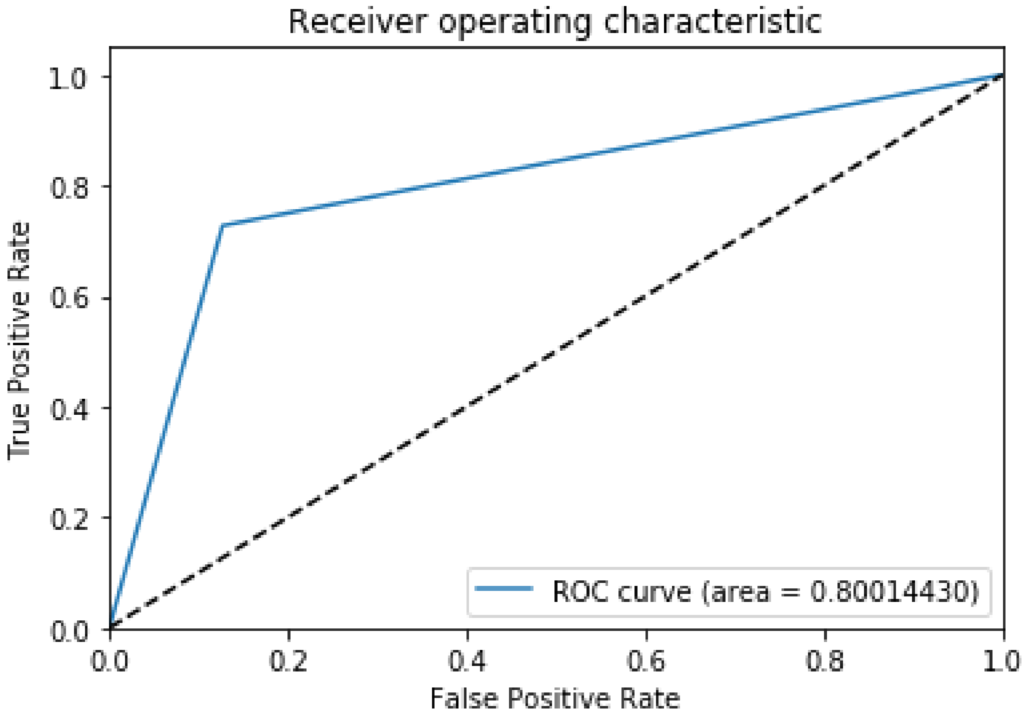

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.74667832)

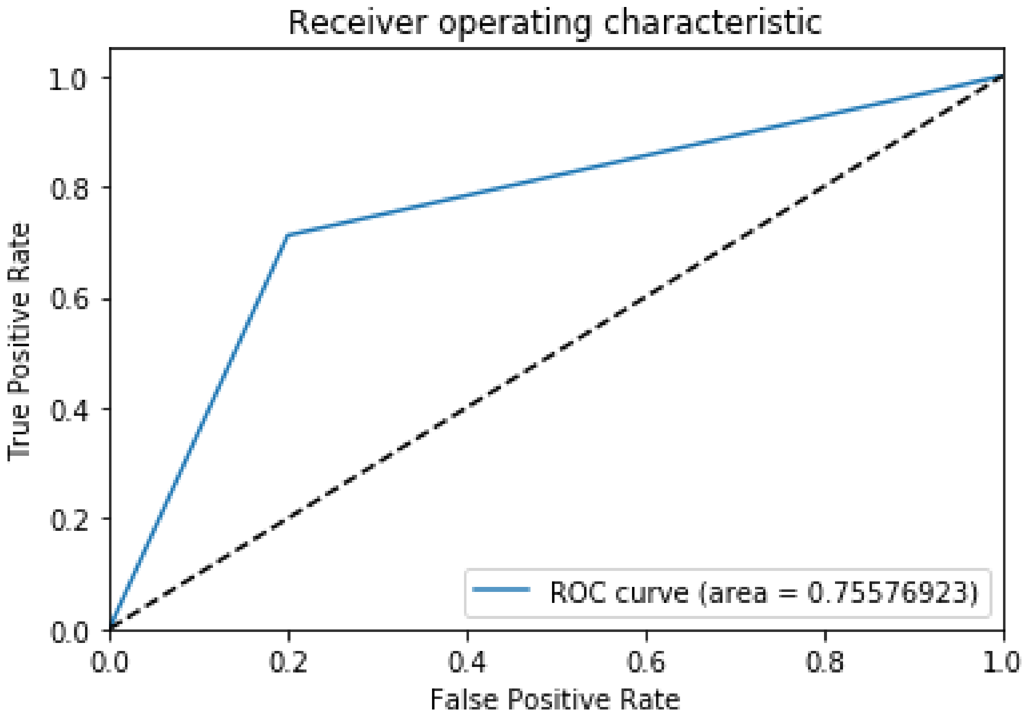

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.72276119)

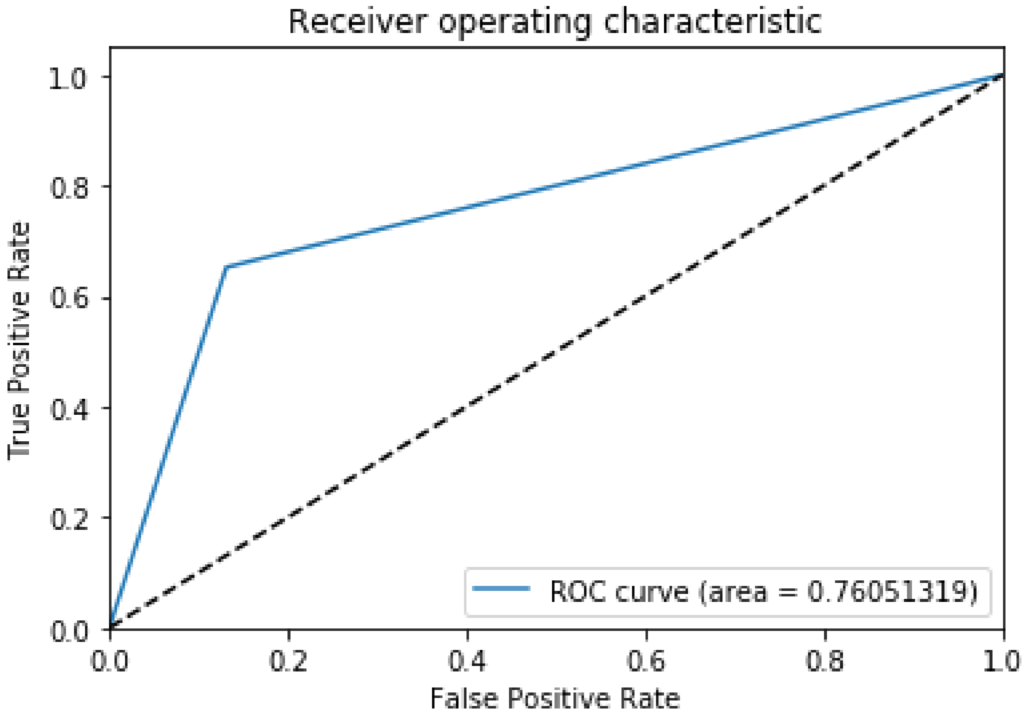

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.82145782)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.80437666)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.88482075)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.80014430)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.75576923)

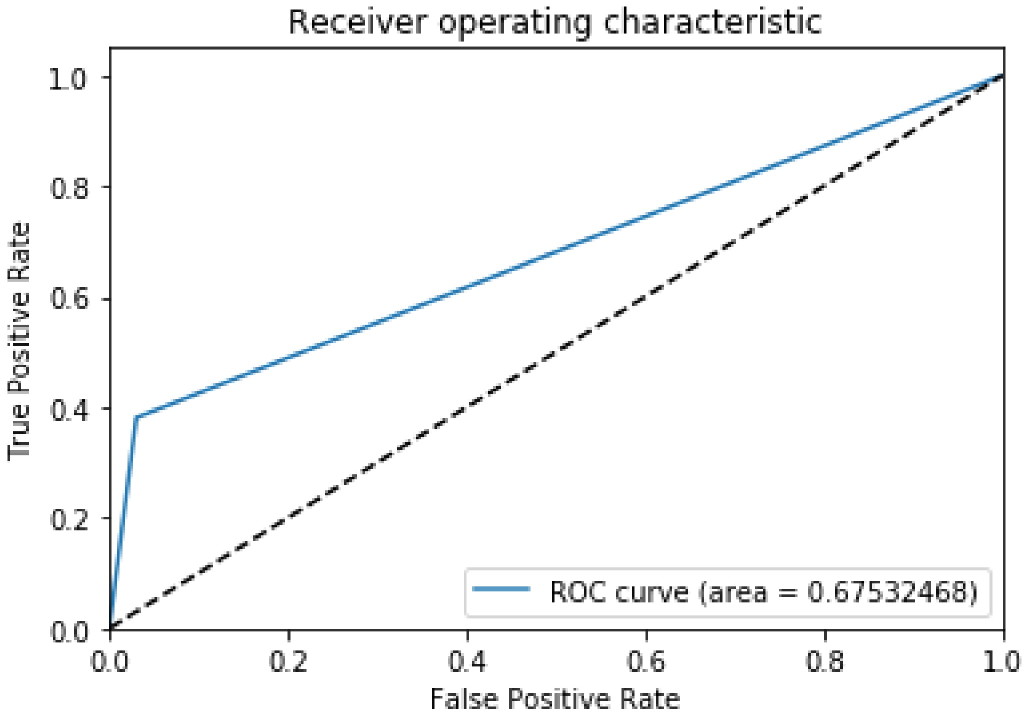

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.76051319)

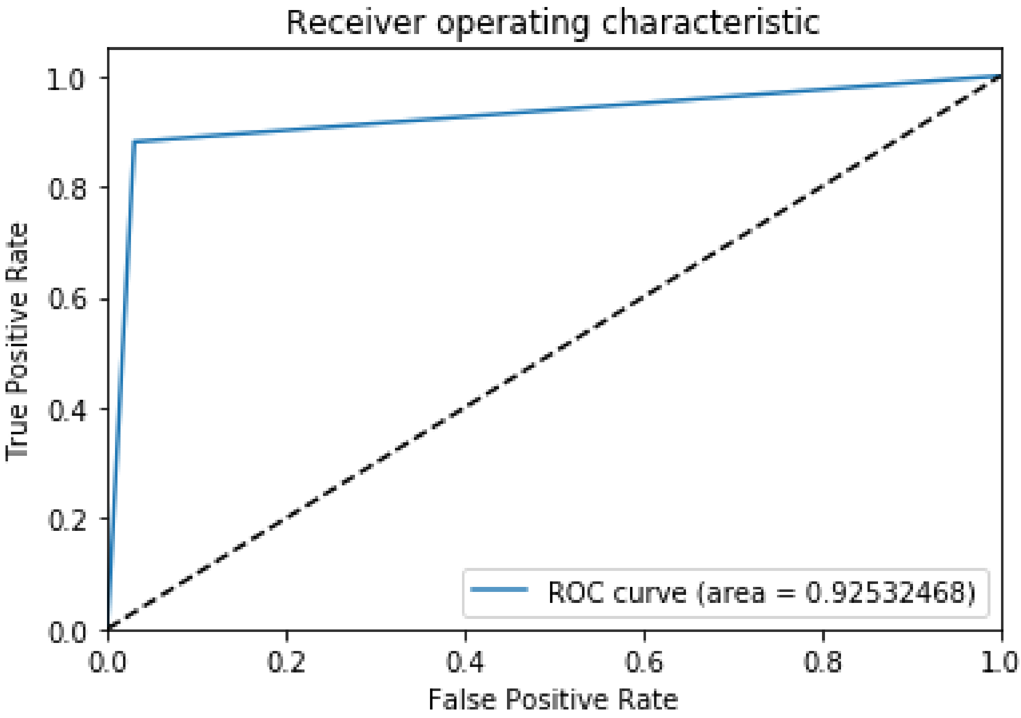
Train using Stratified K Fold

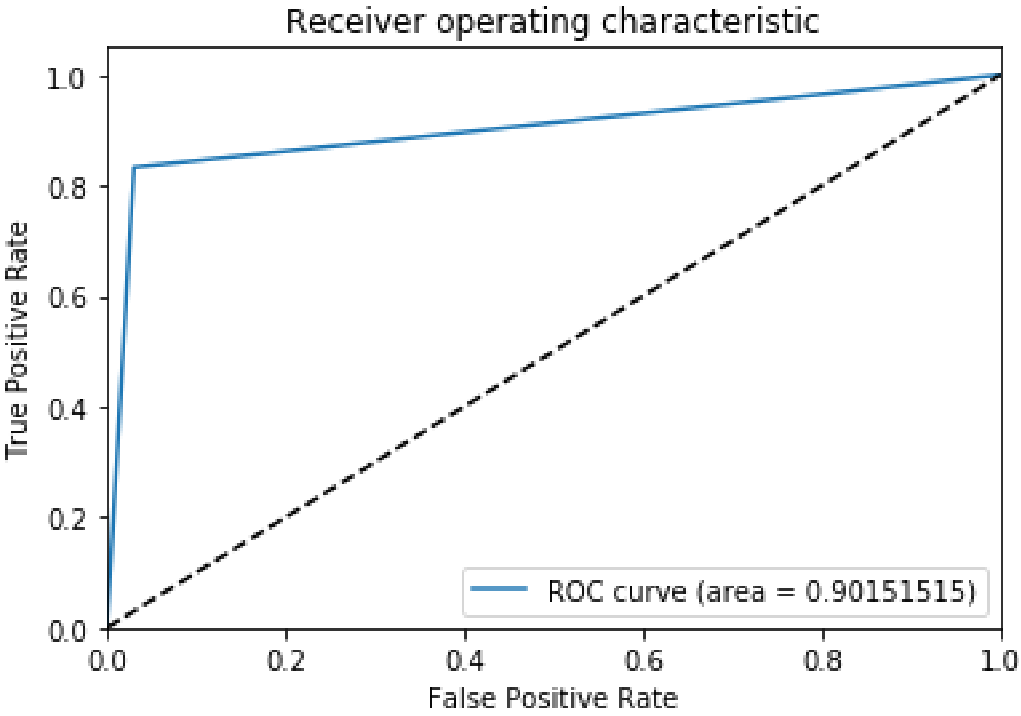
[71]:
```
accuracy_LR_SKF=[]
roc_auc_LR_SKF=[]
```

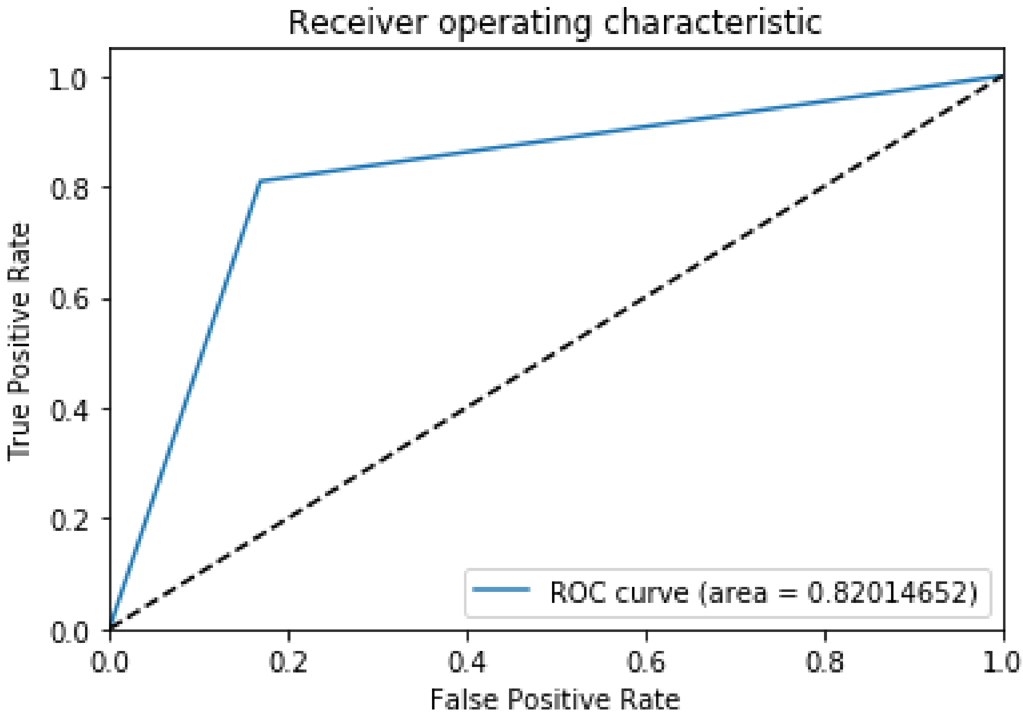
[72]:
```
skf_LR = StratifiedKFold(n_splits=10,random_state=42)
```

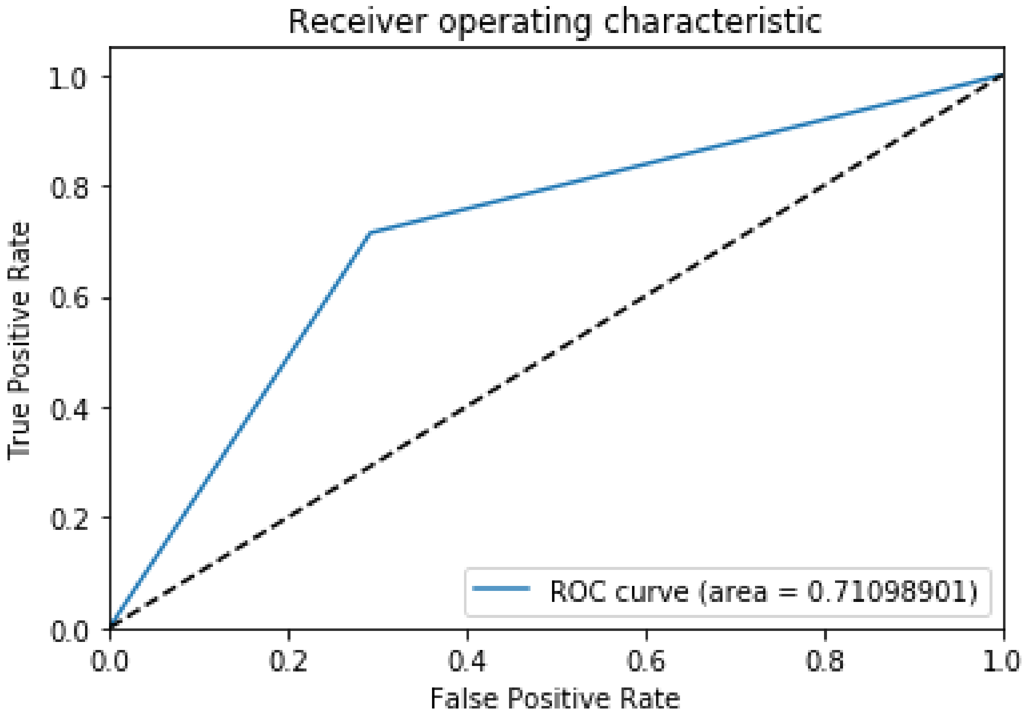
[73]:
```
for train_index,test_index in skf_LR.split(X_LR_SKF,y_LR_SKF):
    X_train_LR_SKF,X_test_LR_SKF,y_train_LR_SKF,y_test_LR_SKF = X_LR_SKF.
 ↪iloc[train_index],X_LR_SKF.iloc[test_index],y_LR_SKF.
 ↪iloc[train_index],y_LR_SKF.iloc[test_index]

    model.fit(X_train_LR_SKF,y_train_LR_SKF)
    y_pred = model.predict(X_test_LR_SKF)
    score=accuracy_score(y_pred,y_test_LR_SKF)
    accuracy_LR_SKF.append(score)
    roc_auc_LR_SKF.append(roc_auc_score(y_test_LR_SKF,y_pred))
    plot_roc_auc(y_test_LR_SKF,y_pred)
```

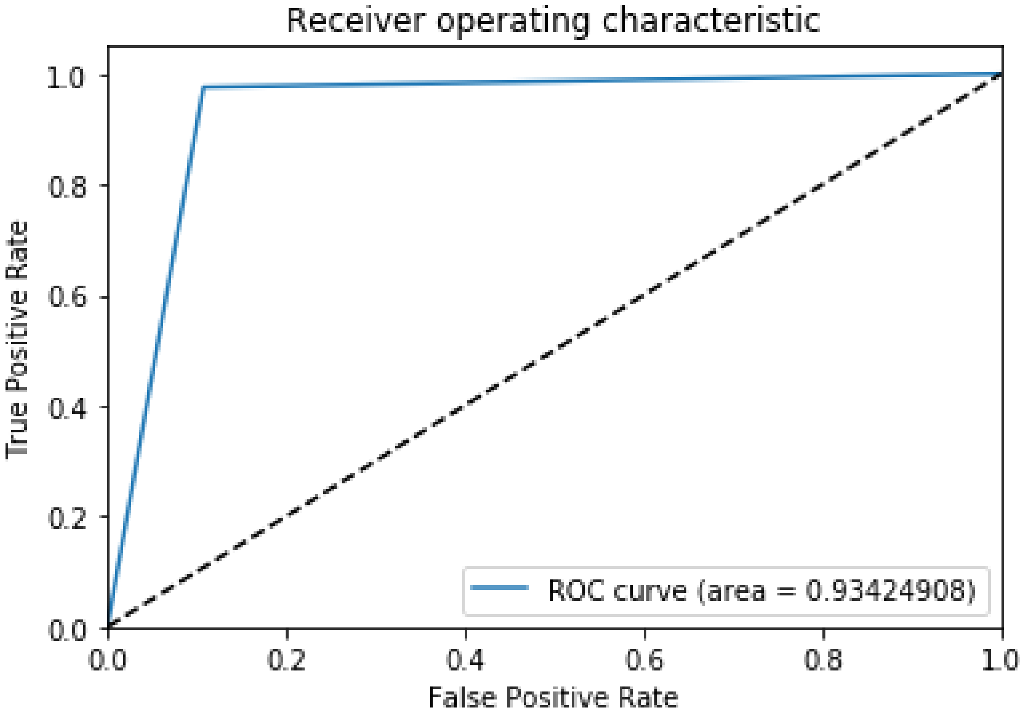


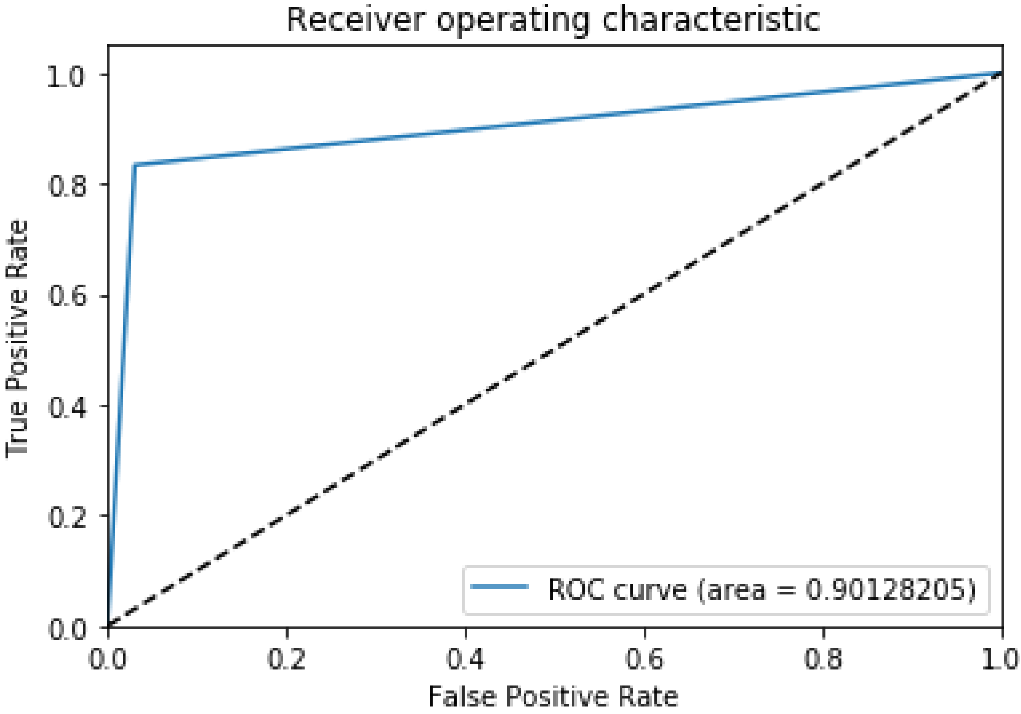

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.92532468)

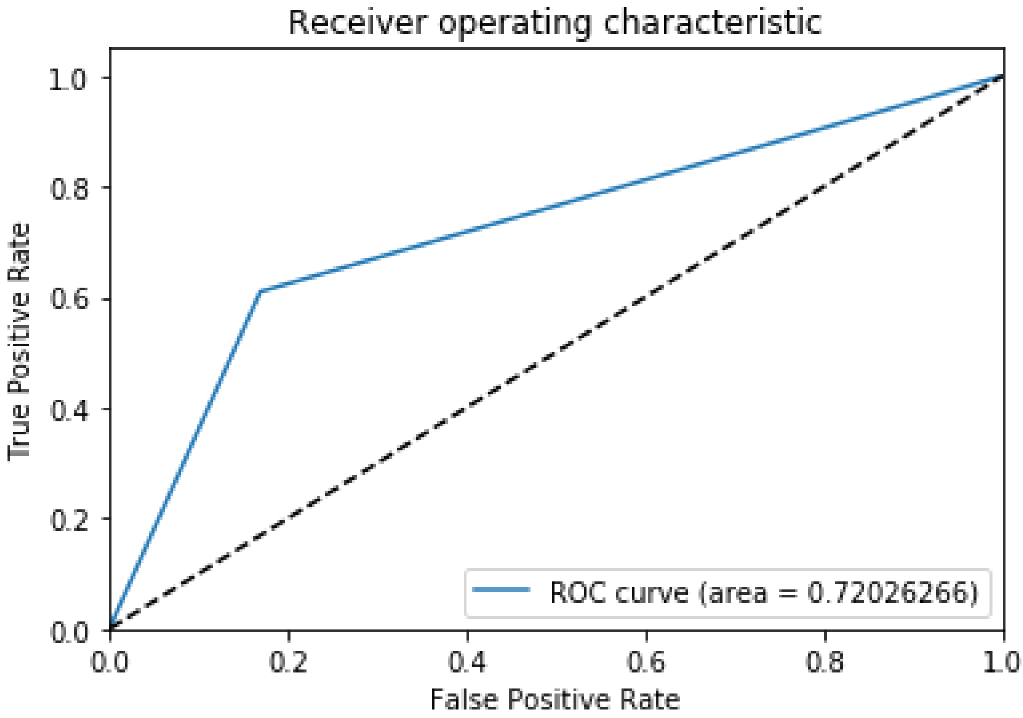

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.90151515)

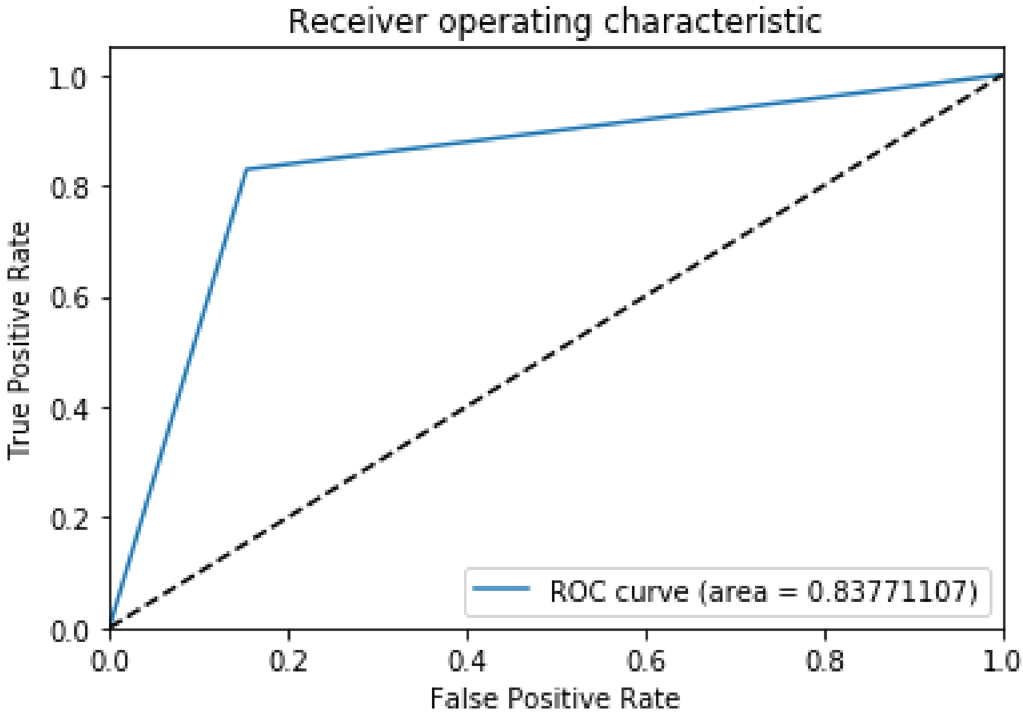

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.82014652)

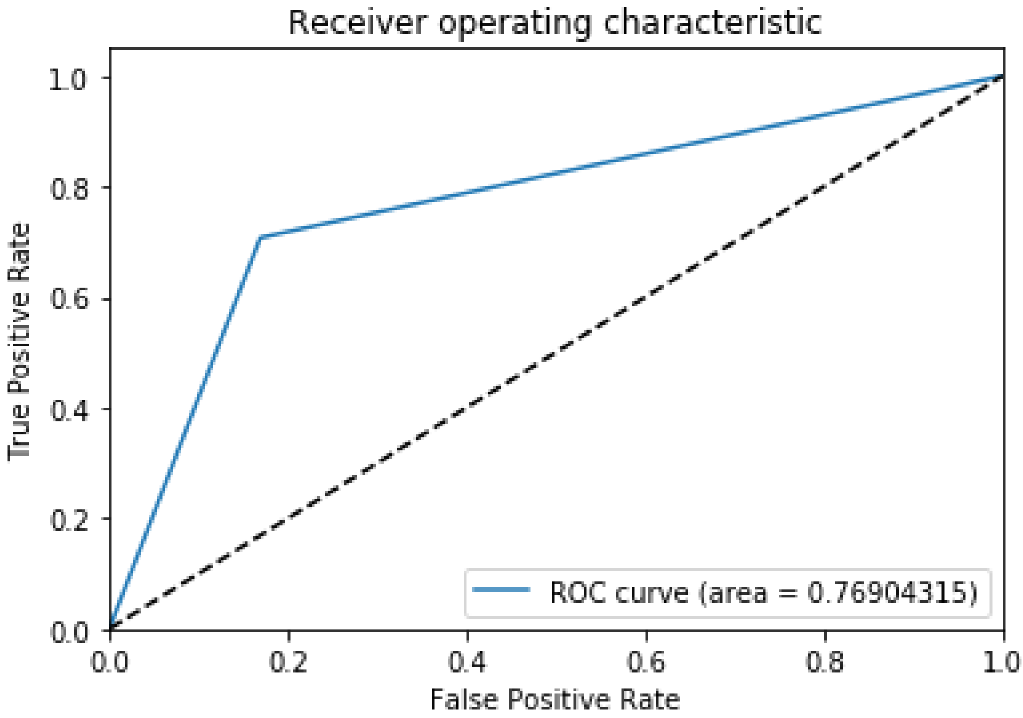

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.71098901)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.93424908)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.90128205)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.72026266)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.83771107)



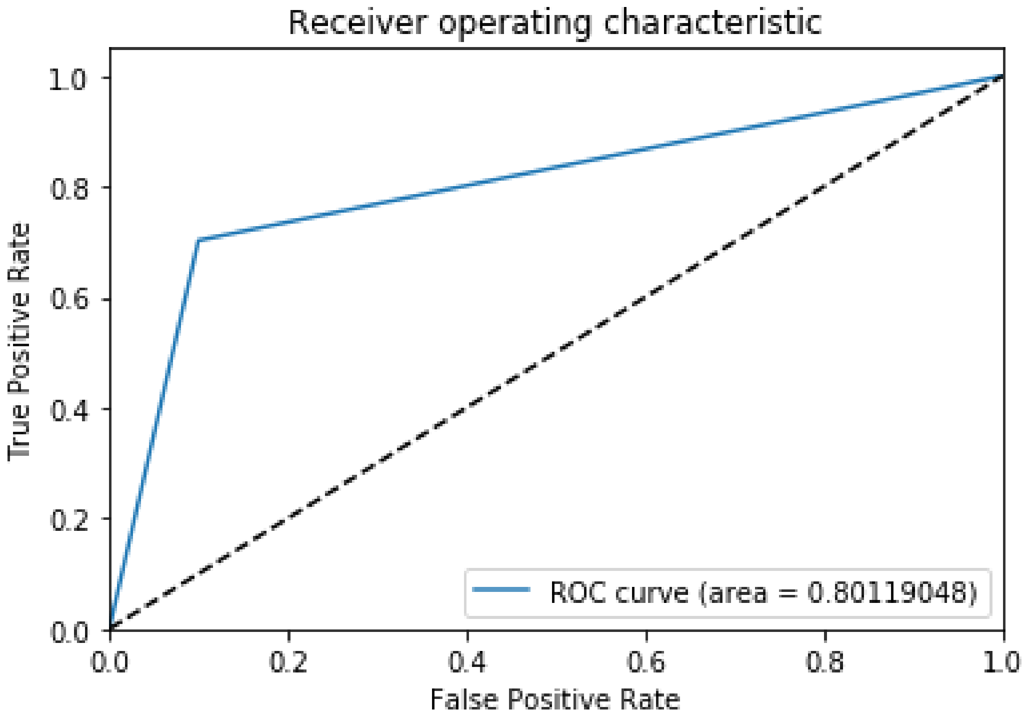
Train using train_test_split

```
[74]: X_train_LR, X_test_LR, y_train_LR, y_test_LR = X_train, X_test, y_train, y_test
      model.fit(X_train_LR,y_train_LR)
```

```
[74]: LogisticRegression(C=8.08397348116461, class_weight=None, dual=False,
                         fit_intercept=True, intercept_scaling=1, l1_ratio=None,
                         max_iter=109, multi_class='warn', n_jobs=None, penalty='l2',
                         random_state=42, solver='newton-cg', tol=0.230893825622149,
                         verbose=0, warm_start=False)
```

Test the classifier

```
[75]: y_pred = model.predict(X_test_LR)
      plot_roc_auc(y_test_LR,y_pred)
```



Evaluate the results

```
[76]: print(np.array(accuracy_LR_KF).mean()) #k fold accuract
```

```
0.8289719626168225
```

```
[77]: print(np.array(roc_auc_LR_KF).mean()) #k fold roc auc
```

```
0.7712289398123645
```

```
[78]: print(np.array(accuracy_LR_SKF).mean()) #stratified k fold accuracy
```

```
0.8334348896595415
```

```
[79]: print(np.array(roc_auc_LR_SKF).mean()) #stratified k fold roc auc
```

```
0.8195848054384639
```

```
[80]: print(accuracy_score(y_pred,y_test_LR)) #train test split
```

```
0.822429906542056
```

```
[81]: print(np.array(cross_val_score(model,X_LR_CV,y_LR_CV,cv=10)).mean()) #cross val
```

```
0.8334348896595415
```

Show other scores from train_test_split()

[82]:
```
print_scores(model.__class__.__name__, y_test_LR, y_pred)
```

```
Model: LogisticRegression
========================================================
*Accuracy score: 0.822429906542056
--------------------------------------------------------
Classification report:
              precision    recall  f1-score   support

           0       0.82      0.90      0.86       130
           1       0.82      0.70      0.76        84

    accuracy                           0.82       214
   macro avg       0.82      0.80      0.81       214
weighted avg       0.82      0.82      0.82       214

--------------------------------------------------------
Confusion matrix:
[[117  13]
 [ 25  59]]
--------------------------------------------------------
Precision score: 0.8194444444444444
--------------------------------------------------------
Recall score: 0.7023809523809523
--------------------------------------------------------
F1 score: 0.7564102564102564
--------------------------------------------------------
Log loss score: 6.133102326042985
--------------------------------------------------------
ROC-AUC score: 0.8011904761904761
--------------------------------------------------------
Sensitivity score: 0.9
--------------------------------------------------------
Specificity score: 0.7023809523809523
```

1.0.4 4. SVM

Determine best parameters for a SVM classifier

[83]:
```
C_range=uniform(0,1)
kernel_options=["linear","poly","rbf","sigmoid"]
degree_range=list(range(3,6))
coef0_range=uniform(loc=0,scale=4)
probability_options=[True,False]
shrinking_options=[True,False]
tol_range=uniform(0,1)
decision_function_shape_options=["ovr","ovo"]
```

```
random_state=[42]

param_grid = dict(
                    C=C_range,
                    kernel=kernel_options,
                    degree=degree_range,
                    coef0=coef0_range,
                    probability=probability_options,
                    shrinking=shrinking_options,
                    tol=tol_range,
                    decision_function_shape=decision_function_shape_options,
                    random_state=random_state
                    )

cross_val = SVC()
grid = RandomizedSearchCV(cross_val, param_grid, random_state=42, n_iter=45,␣
 ↪cv=10, scoring='accuracy', verbose=0)
%time grid.fit(X_GSCV_SVM,y_GSCV_SVM)

print (grid.best_score_)
print (grid.best_params_)
print (grid.best_estimator_)
```

```
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```

```
Wall time: 1min 6s
0.8345794392523365
{'C': 0.9385527090157502, 'coef0': 0.0031150633640573133,
'decision_function_shape': 'ovo', 'degree': 3, 'kernel': 'linear',
'probability': False, 'random_state': 42, 'shrinking': False, 'tol':
0.5247564316322378}
SVC(C=0.9385527090157502, cache_size=200, class_weight=None,
    coef0=0.0031150633640573133, decision_function_shape='ovo', degree=3,
    gamma='auto_deprecated', kernel='linear', max_iter=-1, probability=False,
    random_state=42, shrinking=False, tol=0.5247564316322378, verbose=False)
```

```
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\model_selection\_search.py:813: DeprecationWarning: The default
of the `iid` parameter will change from True to False in version 0.22 and will
be removed in 0.24. This will change numeric results when test-set sizes are
unequal.
  DeprecationWarning)
```

Create a SVM classifier

[84]:

```
model=SVC(C=0.9385527090157502, cache_size=200, class_weight=None,
    coef0=0.0031150633640573133, decision_function_shape='ovo', degree=3,
    gamma='auto_deprecated', kernel='linear', max_iter=-1, probability=False,
    random_state=42, shrinking=False, tol=0.5247564316322378, verbose=False)
```

Testing using K Fold

[85]:

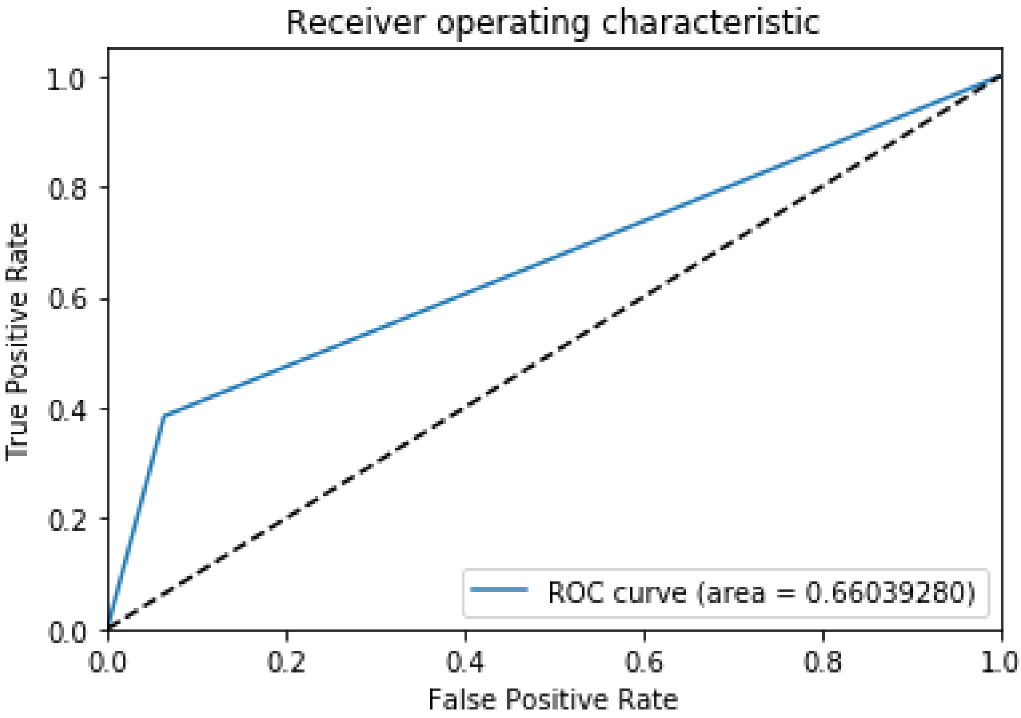
```
accuracy_SVM_KF=[]
roc_auc_SVM_KF=[]
```

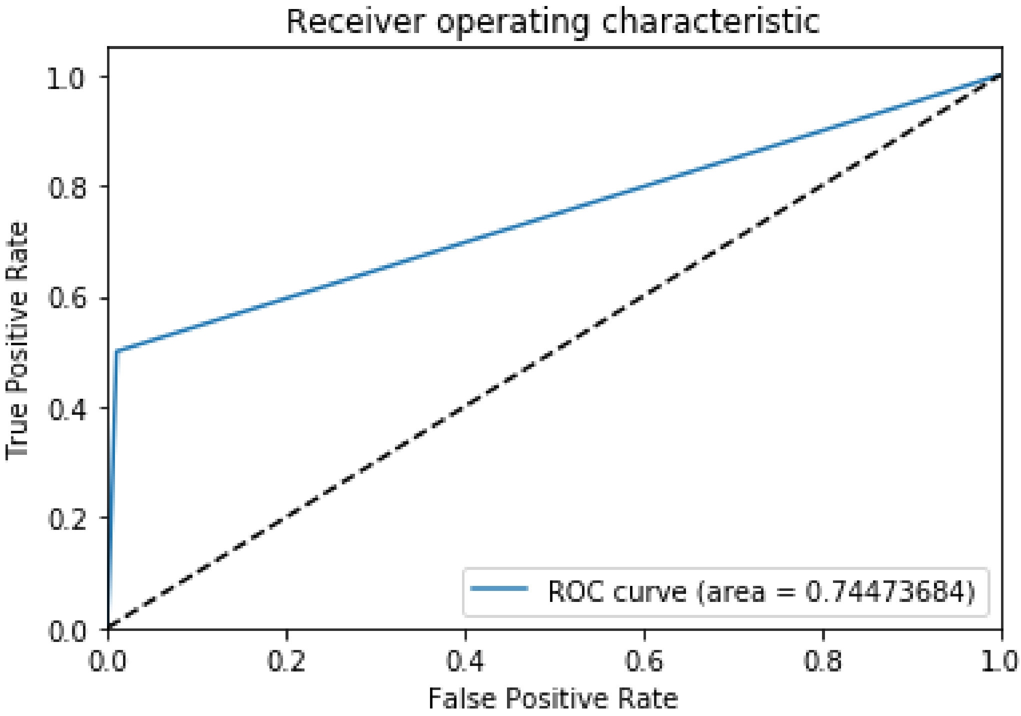
[86]:

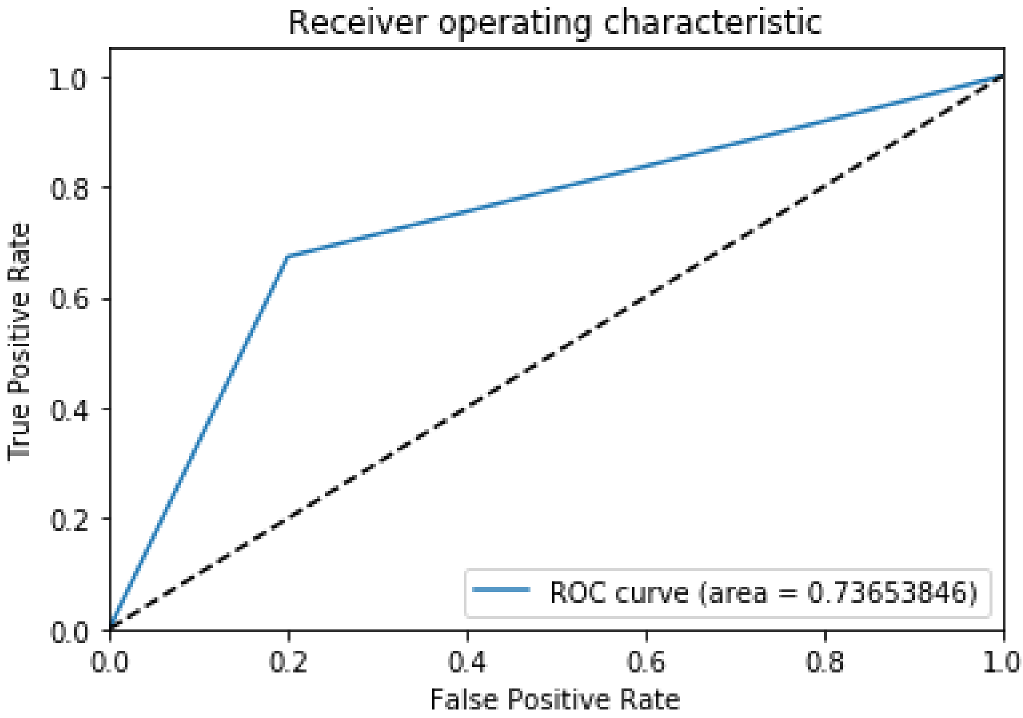
```
kf_SVM = KFold(n_splits=10,random_state=42)
```

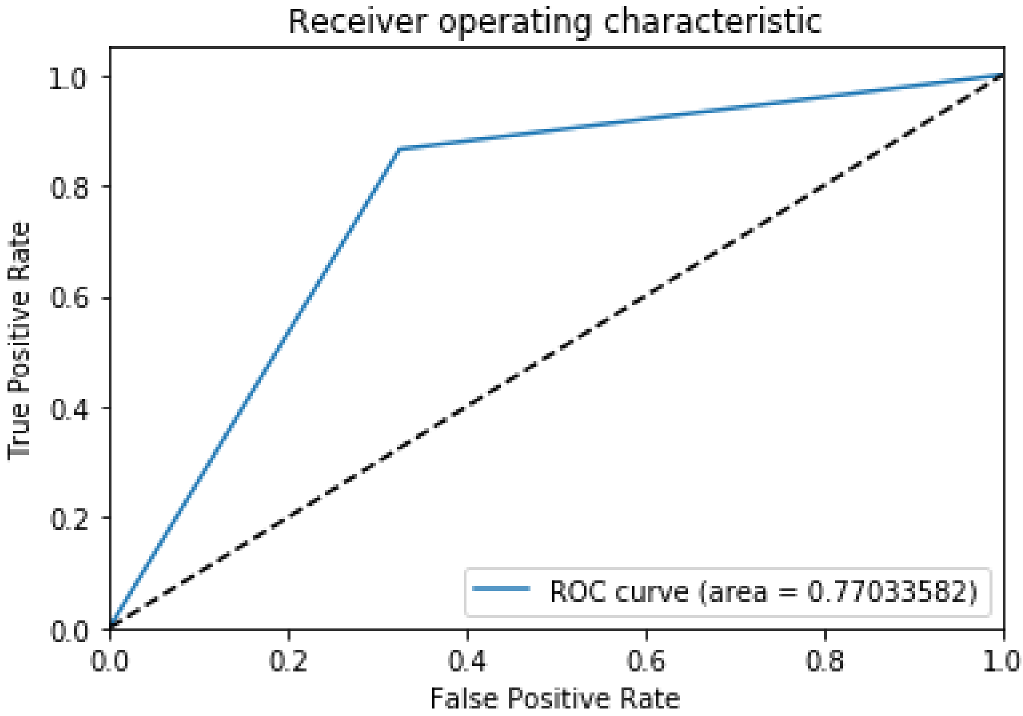
[87]:

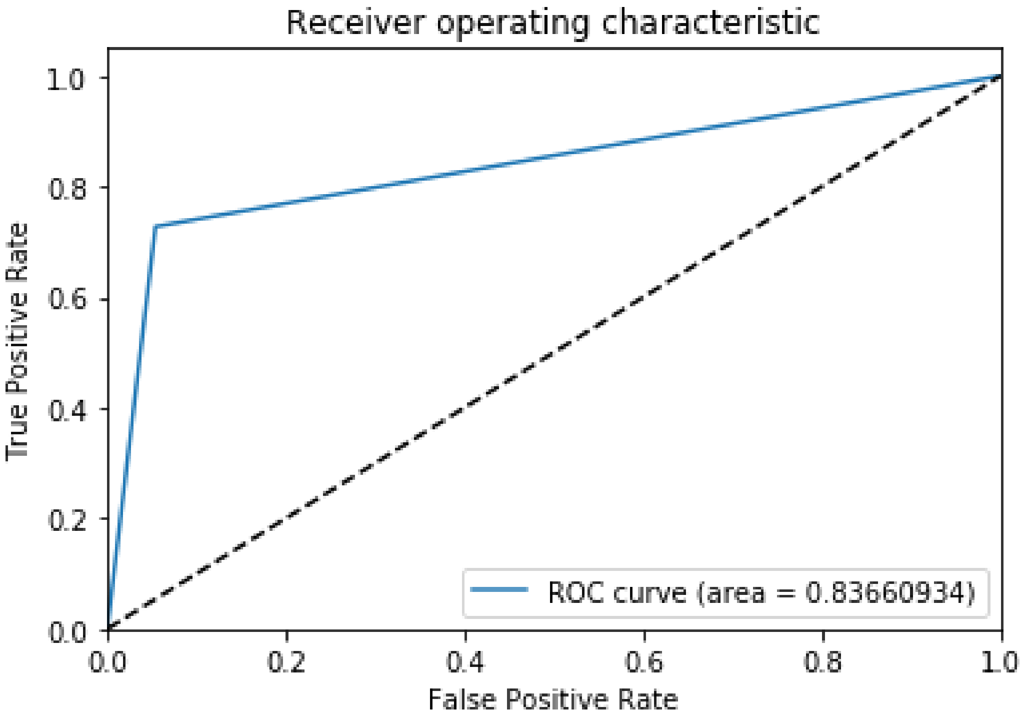
```
for train_index,test_index in kf_SVM.split(X_SVM_KF,y_SVM_KF):
    X_train_SVM_KF,X_test_SVM_KF,y_train_SVM_KF,y_test_SVM_KF = X_SVM_KF.
 ↪iloc[train_index],X_SVM_KF.iloc[test_index],y_SVM_KF.
 ↪iloc[train_index],y_SVM_KF.iloc[test_index]

    model.fit(X_train_SVM_KF,y_train_SVM_KF)
    y_pred = model.predict(X_test_SVM_KF)
    score=accuracy_score(y_pred,y_test_SVM_KF)
    accuracy_SVM_KF.append(score)
    roc_auc_SVM_KF.append(roc_auc_score(y_test_SVM_KF,y_pred))
    plot_roc_auc(y_test_SVM_KF,y_pred)
```

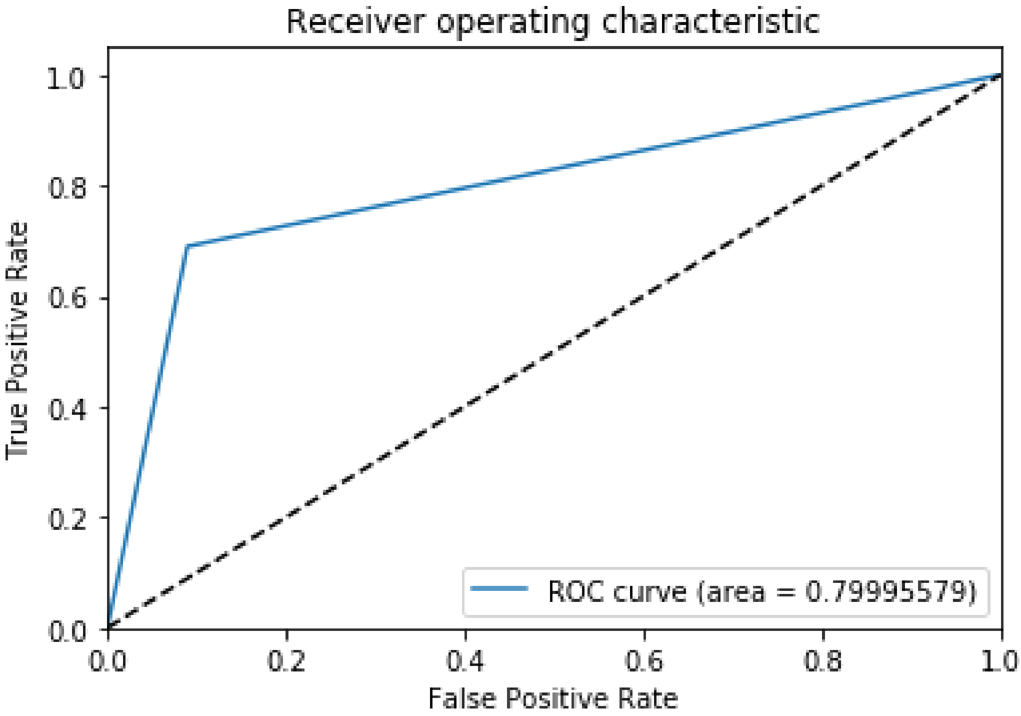

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.66039280)

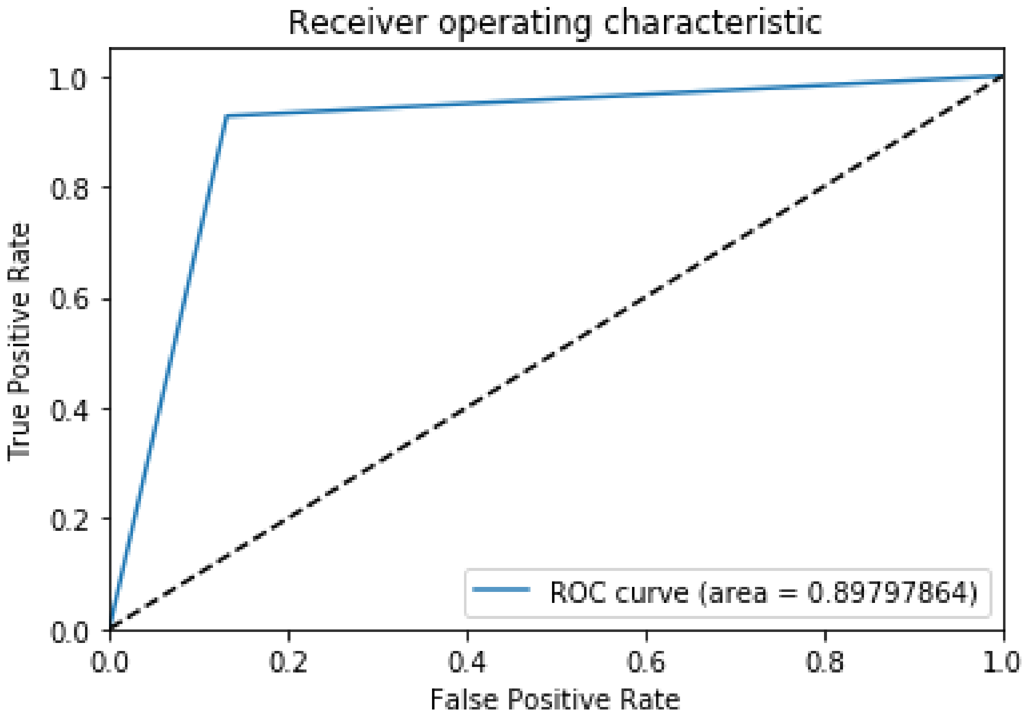

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.74473684)

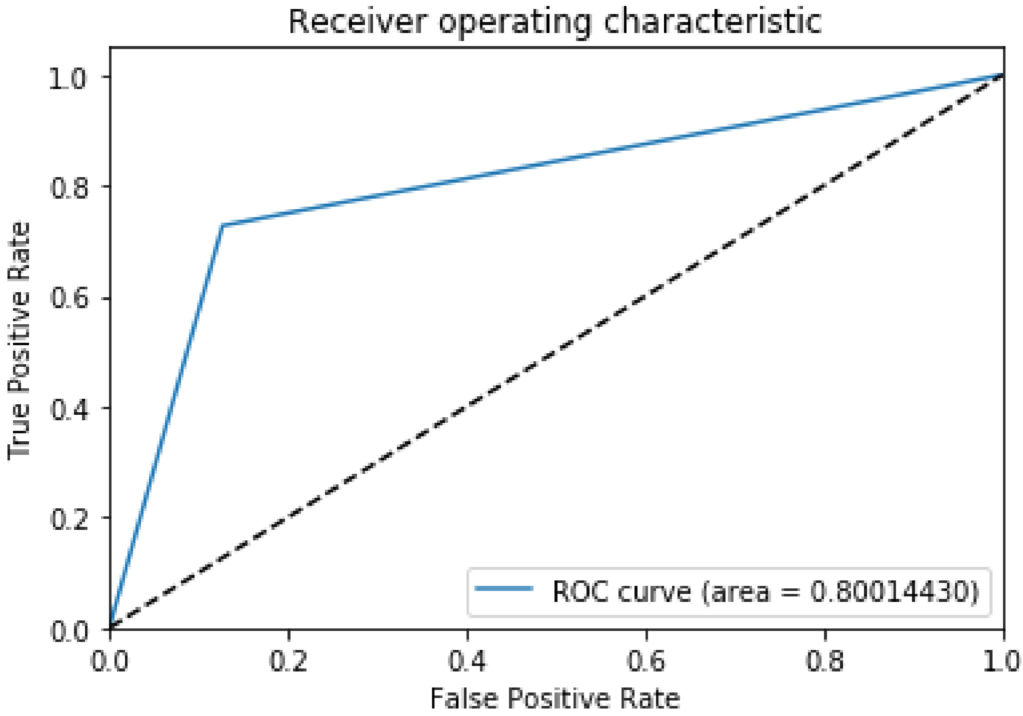

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.73653846)

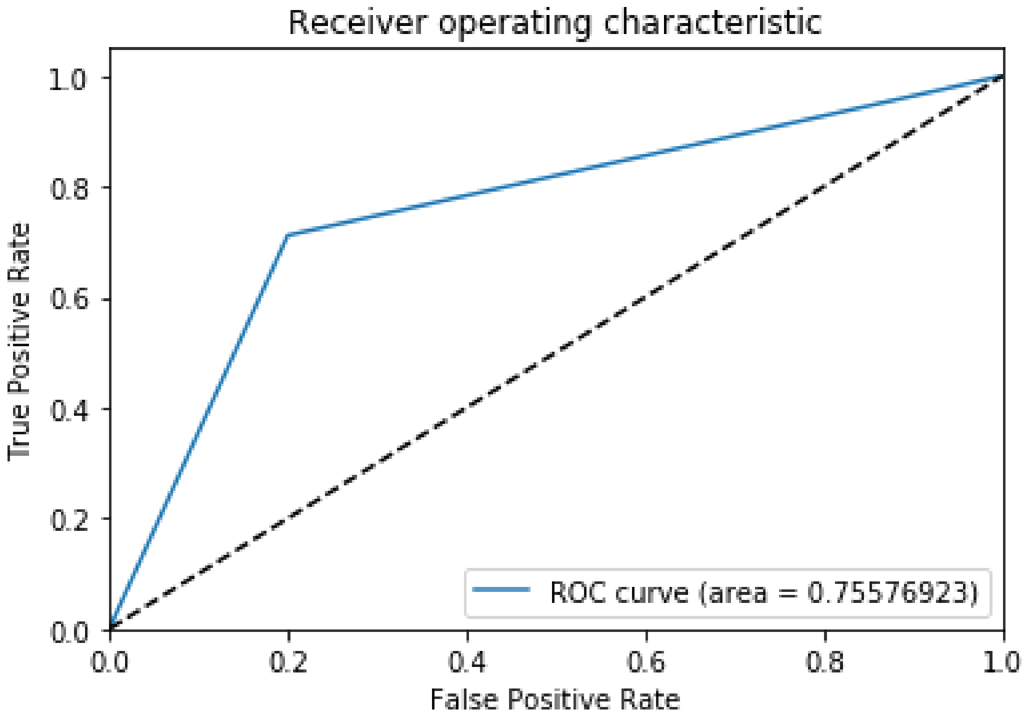

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.77033582)

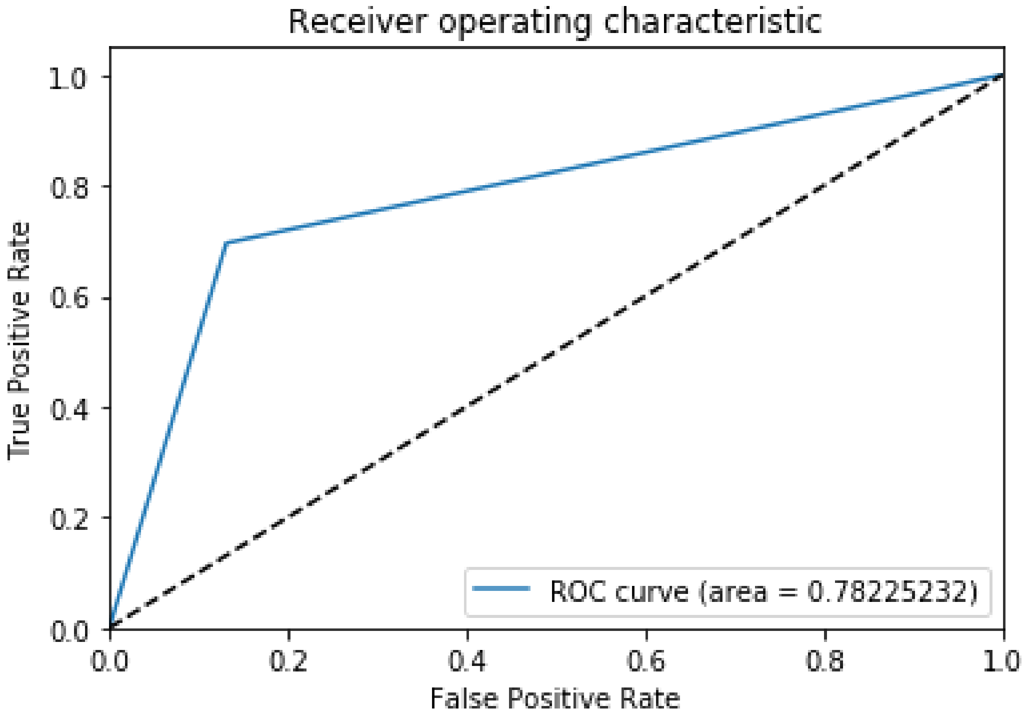

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.83660934)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.79995579)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.89797864)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.80014430)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.75576923)

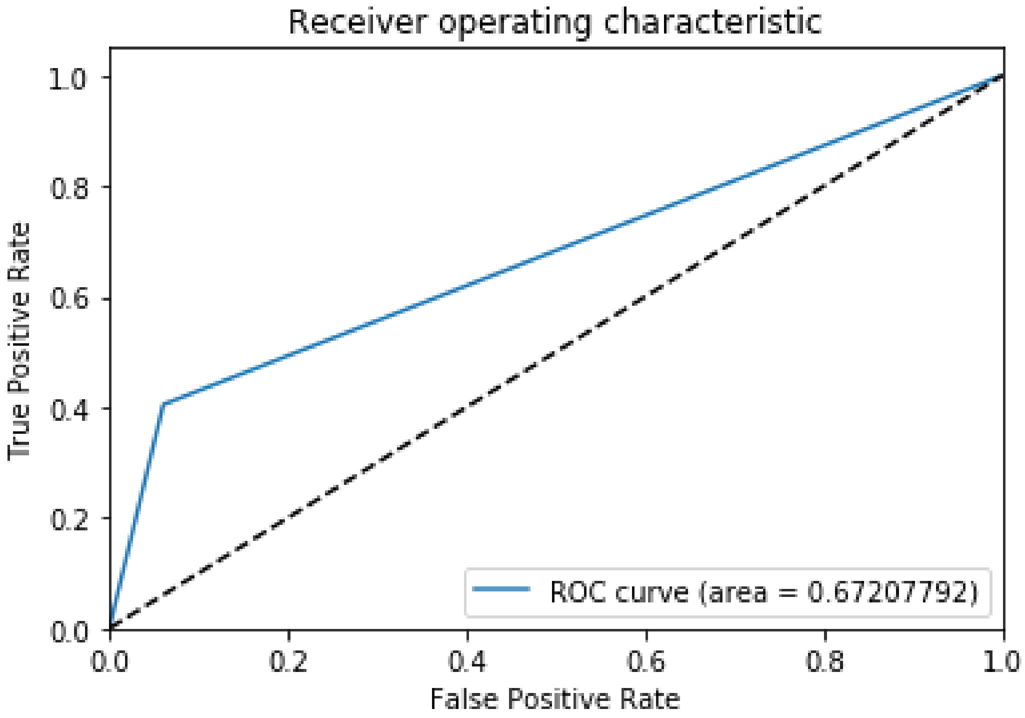

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.78225232)

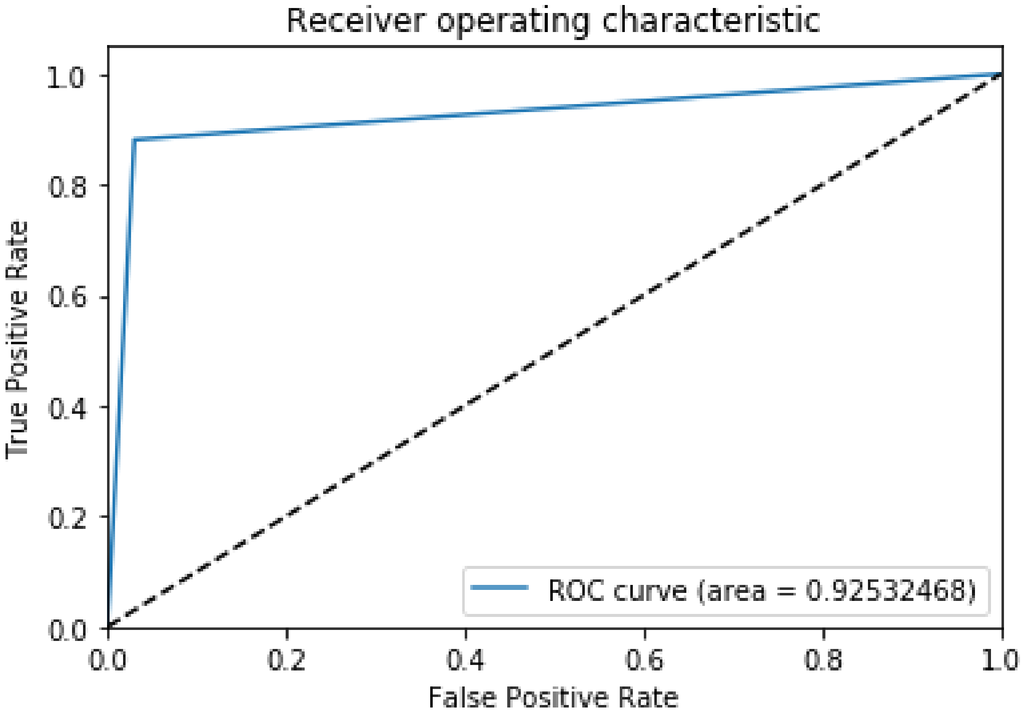
Testing using Stratified K Fold

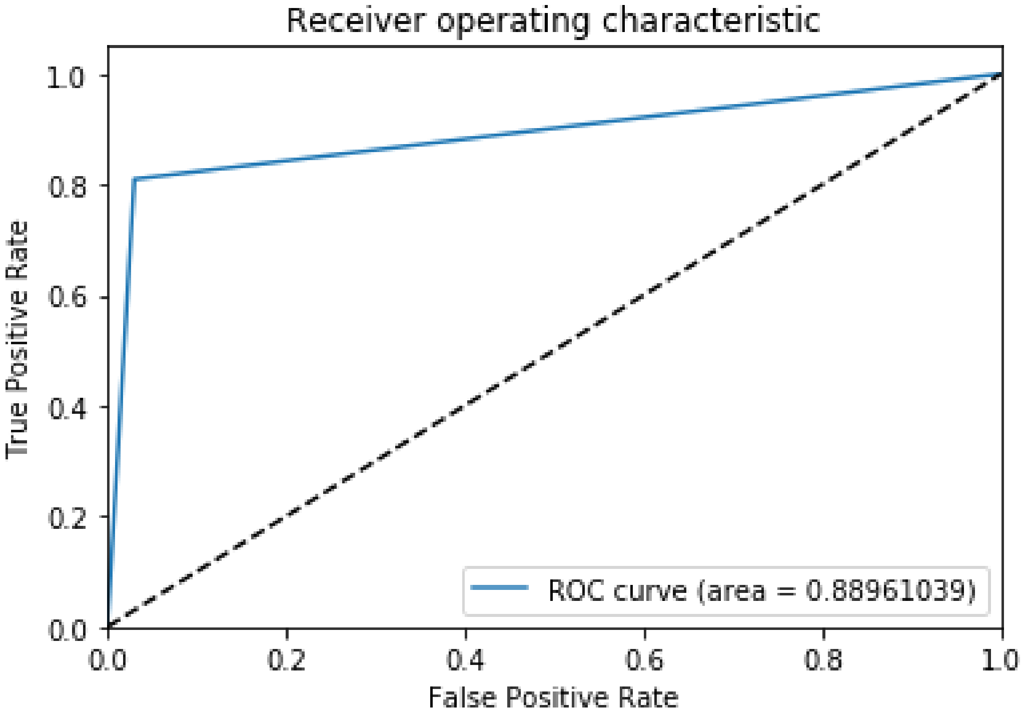
[88]:
```
accuracy_SVM_SKF=[]
roc_auc_SVM_SKF=[]
```

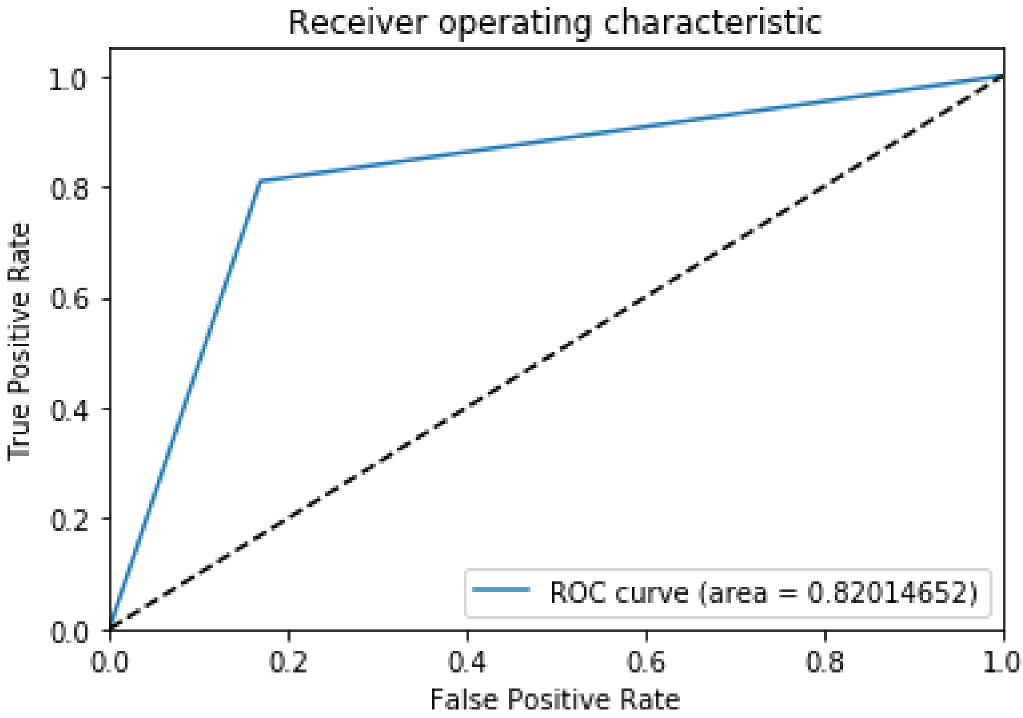
[89]:
```
skf_SVM = StratifiedKFold(n_splits=10,random_state=42)
```

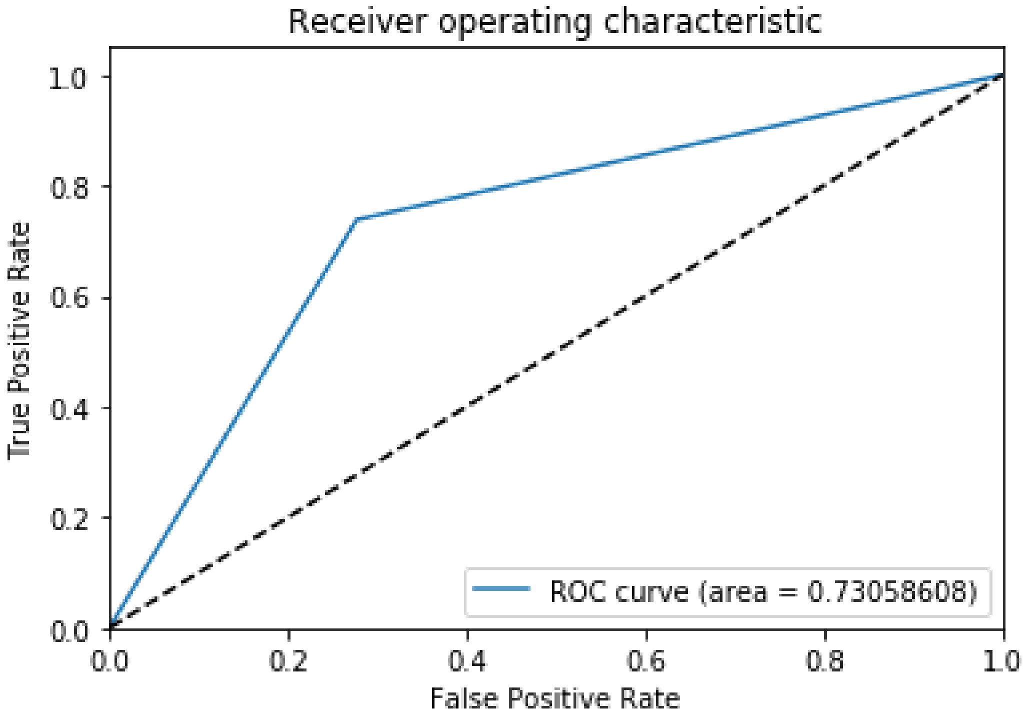
[90]:
```
for train_index,test_index in skf_SVM.split(X_SVM_SKF,y_SVM_SKF):
    X_train_SVM_SKF,X_test_SVM_SKF,y_train_SVM_SKF,y_test_SVM_SKF = X_SVM_SKF.
 ↪iloc[train_index],X_SVM_SKF.iloc[test_index],y_SVM_SKF.
 ↪iloc[train_index],y_SVM_SKF.iloc[test_index]

    model.fit(X_train_SVM_SKF,y_train_SVM_SKF)
    y_pred = model.predict(X_test_SVM_SKF)
    score=accuracy_score(y_pred,y_test_SVM_SKF)
    accuracy_SVM_SKF.append(score)
    roc_auc_SVM_SKF.append(roc_auc_score(y_test_SVM_SKF,y_pred))
    plot_roc_auc(y_test_SVM_SKF,y_pred)
```

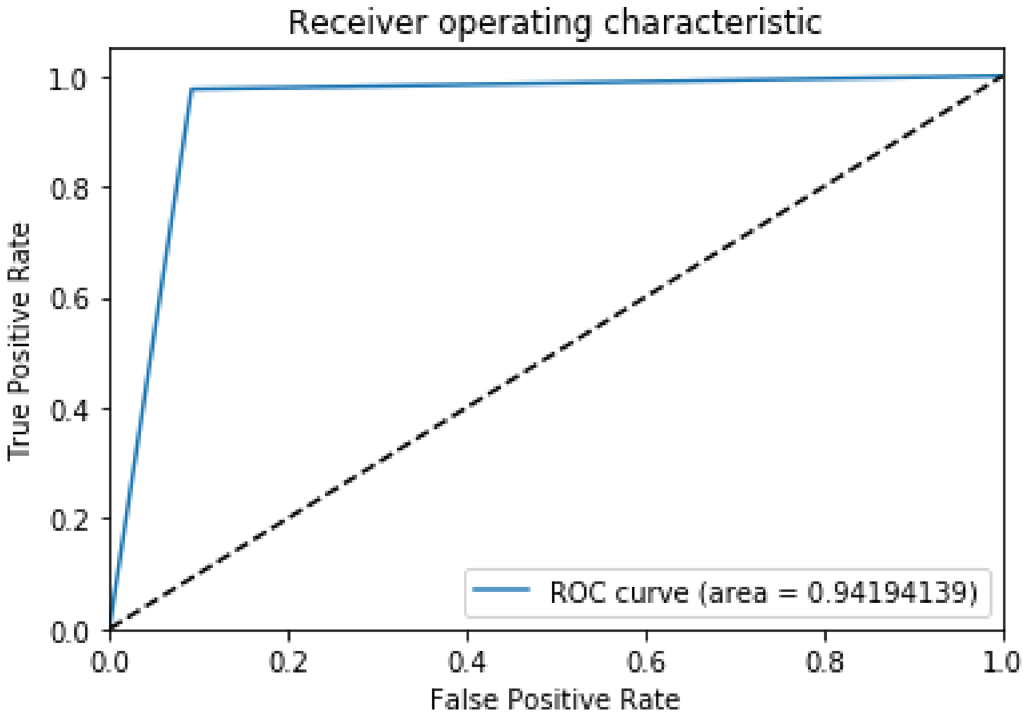


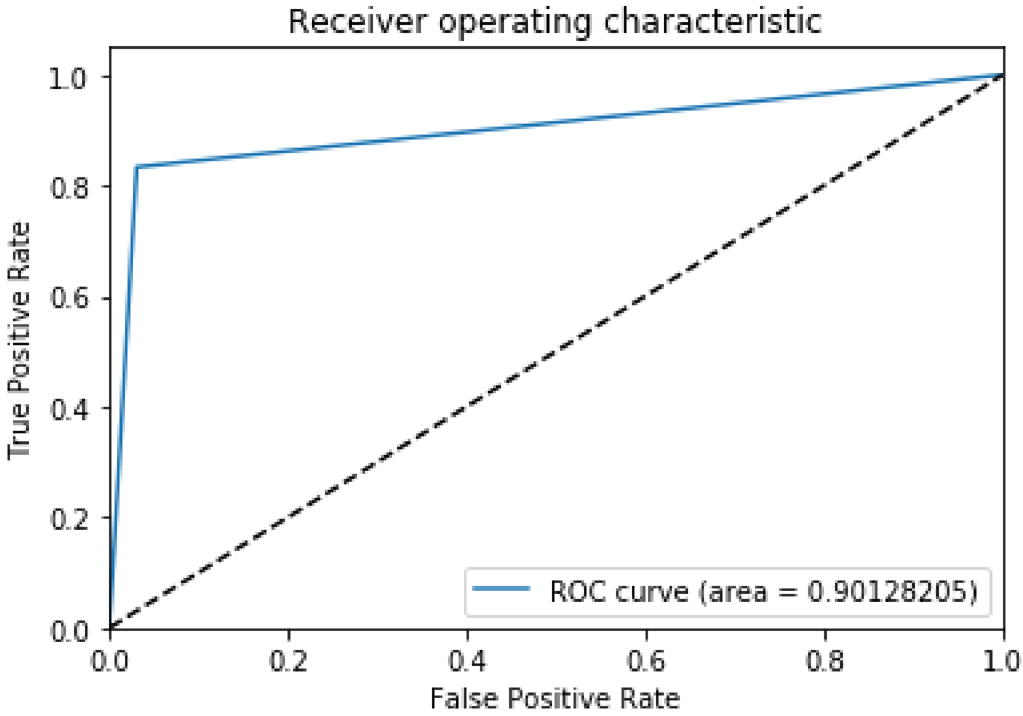

Receiver operating characteristic
True Positive Rate
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
ROC curve (area = 0.92532468)

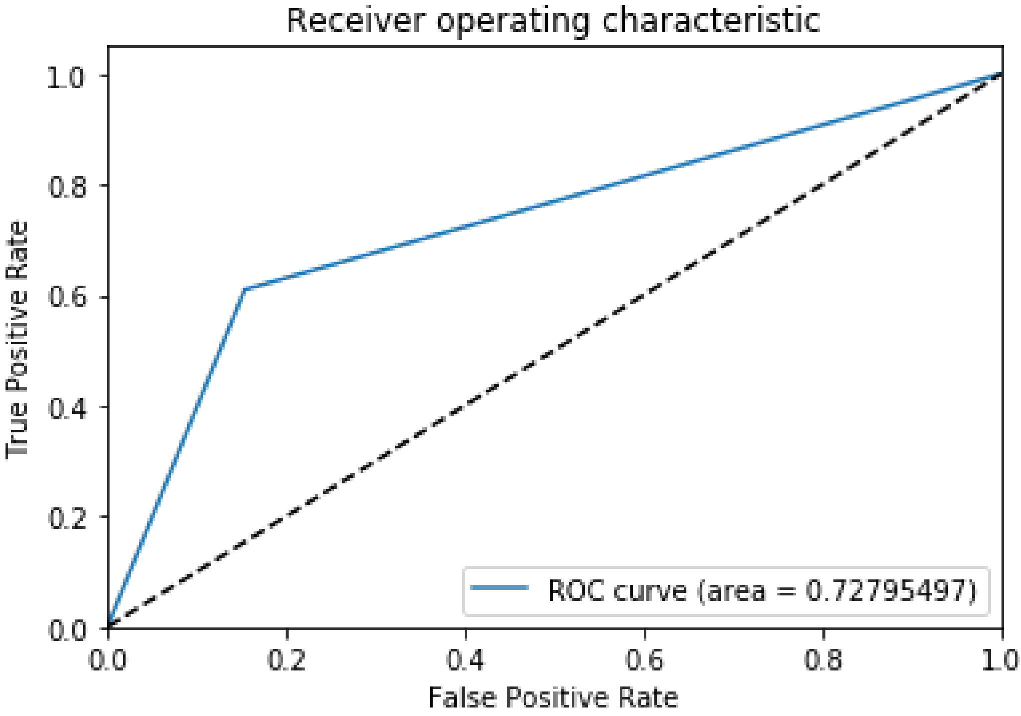

Receiver operating characteristic
True Positive Rate
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate
ROC curve (area = 0.88961039)

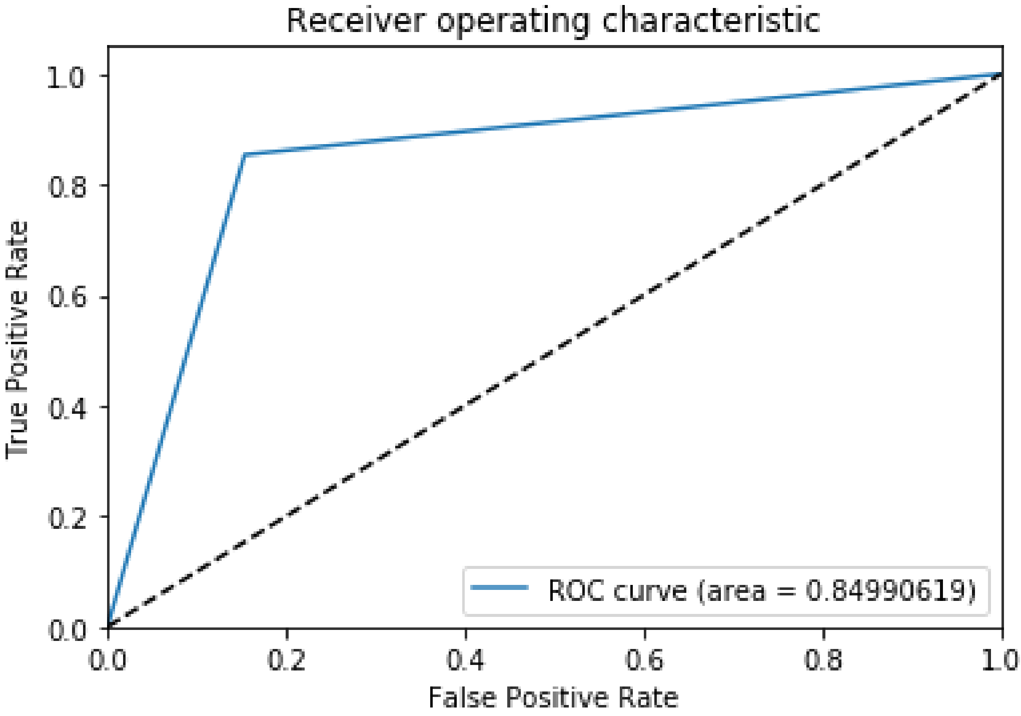

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.82014652)

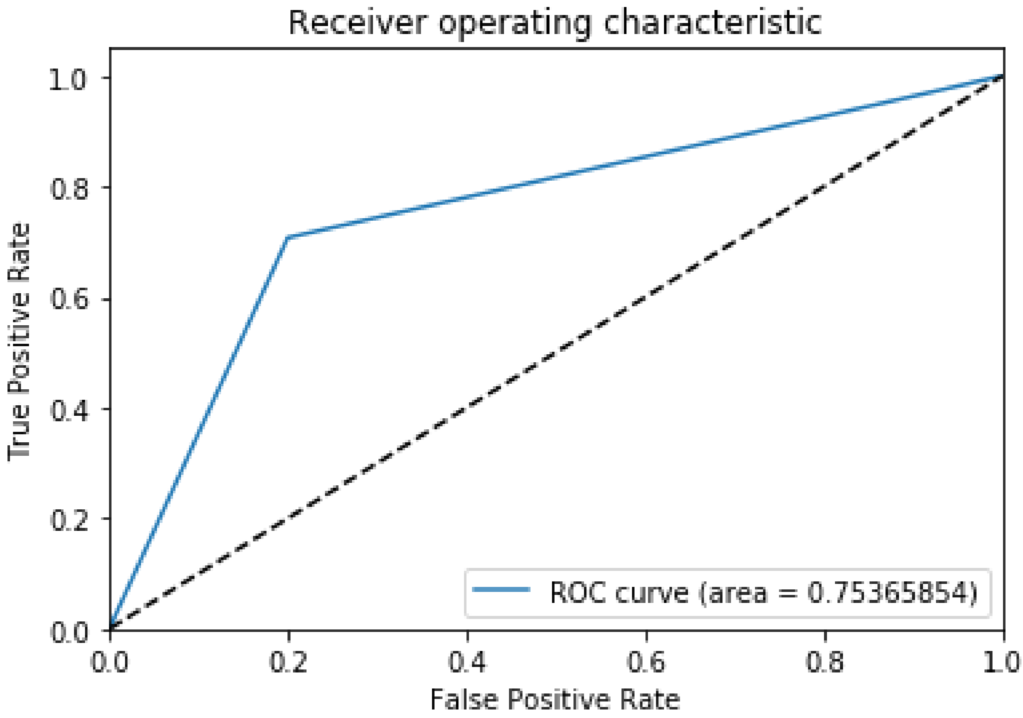

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.73058608)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.94194139)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.90128205)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.72795497)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.84990619)



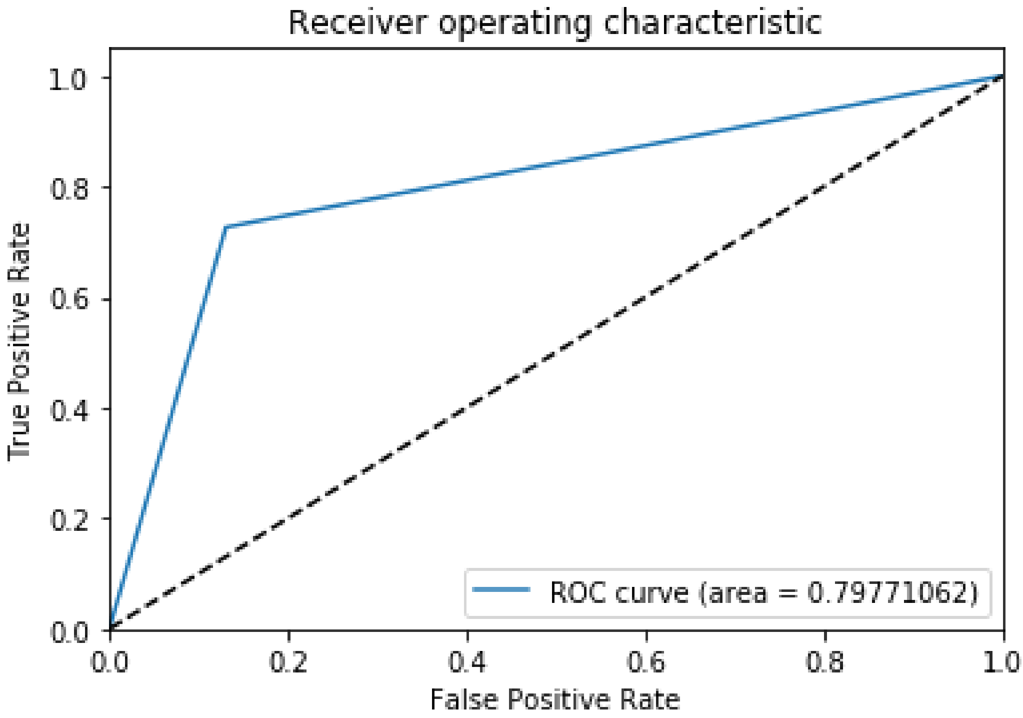
Train using train_test_split

```
[91]: X_train_SVM, X_test_SVM, y_train_SVM, y_test_SVM = X_train, X_test, y_train,␣
       ↪y_test
      model.fit(X_train_SVM,y_train_SVM)
```

```
[91]: SVC(C=0.9385527090157502, cache_size=200, class_weight=None,
          coef0=0.0031150633640573133, decision_function_shape='ovo', degree=3,
          gamma='auto_deprecated', kernel='linear', max_iter=-1, probability=False,
          random_state=42, shrinking=False, tol=0.5247564316322378, verbose=False)
```

Test the classifier

```
[92]: y_pred = model.predict(X_test_SVM)
      plot_roc_auc(y_test_SVM,y_pred)
```



Evaluate the results

```
[93]: print(np.array(accuracy_SVM_KF).mean()) #k fold accuracy
```

```
0.833644859813084
```

```
[94]: print(np.array(roc_auc_SVM_KF).mean()) #k fold roc_auc
```

```
0.7784713540810424
```

```
[95]: print(np.array(accuracy_SVM_SKF).mean()) #stratified k fold
```

```
0.8343867761254465
```

```
[96]: print(np.array(roc_auc_SVM_SKF).mean()) #stratified k fold roc_auc
```

```
0.8212488730781413
```

```
[97]: print(accuracy_score(y_pred,y_test_SVM)) #train test split
```

```
0.8130841121495327
```

```
[98]: print(np.array(cross_val_score(model,X_SVM_CV,y_SVM_CV,cv=10)).mean()) #cross␣
      ↪val
```

```
0.8343867761254465
```

Show other scores from train_test_split

[99]:
```
print_scores(model.__class__.__name__, y_test_SVM, y_pred)
```

```
Model: SVC
========================================================
*Accuracy score: 0.8130841121495327
--------------------------------------------------------
Classification report:
              precision    recall  f1-score   support

           0       0.83      0.87      0.85       130
           1       0.78      0.73      0.75        84

    accuracy                           0.81       214
   macro avg       0.81      0.80      0.80       214
weighted avg       0.81      0.81      0.81       214

--------------------------------------------------------
Confusion matrix:
[[113  17]
 [ 23  61]]
--------------------------------------------------------
Precision score: 0.782051282051282
--------------------------------------------------------
Recall score: 0.7261904761904762
--------------------------------------------------------
F1 score: 0.7530864197530864
--------------------------------------------------------
Log loss score: 6.455909574545518
--------------------------------------------------------
ROC-AUC score: 0.7977106227106228
--------------------------------------------------------
Sensitivity score: 0.8692307692307693
--------------------------------------------------------
Specificity score: 0.7261904761904762
```

1.0.5 5. XGBoost

Determine best parameters for a XGBoost classifier

[100]:
```
max_depth_range=list(range(3,10))
learning_rate_range=uniform(0,1)
n_estimators_range=list(range(100,110))
booster_options=["gbtree","gblinear","dart"]
gamma_range=uniform(0,1)
min_child_weight_range=list(range(1,10))
```

```
max_delta_step_range=list(range(0,10))
subsample_range=uniform(0,1)
colsample_bytree_range=list(range(0,2))
colsample_bylevel_range=list(range(0,2))
colsample_bynode_range=list(range(0,2))
reg_alpha_range=uniform(0,1)
reg_lambda_range=uniform(0,1)
scale_pos_weight_range=uniform(0,1)
random_state_option=[42]
importance_type_options=["gain","weight","cover","total_gain","total_cover"]


param_grid = dict(
                    max_depth=max_depth_range,
                    learning_rate=learning_rate_range,
                    n_estimators=n_estimators_range,
                    booster=booster_options,
                    gamma=gamma_range,
                    min_child_weight=min_child_weight_range,
                    max_delta_step=max_delta_step_range,
                    subsample=subsample_range,
                    colsample_bytree=colsample_bytree_range,
                    colsample_bylevel=colsample_bylevel_range,
                    colsample_bynode=colsample_bynode_range,
                    reg_alpha=reg_alpha_range,
                    reg_lambda=reg_lambda_range,
                    scale_pos_weight=scale_pos_weight_range,
                    random_state=random_state_option,
                    importance_type=importance_type_options
                    )

cross_val = XGBClassifier()
grid = RandomizedSearchCV(cross_val, param_grid, random_state=42, n_iter=100,␣
 ↪cv=10, scoring='accuracy', verbose=0)
%time grid.fit(X_GSCV_XGB,y_GSCV_XGB)

print (grid.best_score_)
print (grid.best_params_)
print (grid.best_estimator_)
```

```
C:\Users\Owner\Anaconda3\lib\site-
packages\sklearn\model_selection\_search.py:813: DeprecationWarning: The default
of the `iid` parameter will change from True to False in version 0.22 and will
be removed in 0.24. This will change numeric results when test-set sizes are
unequal.
  DeprecationWarning)
```

```
Wall time: 3min 42s
```

```
0.822429906542056
{'booster': 'dart', 'colsample_bylevel': 1, 'colsample_bynode': 0,
'colsample_bytree': 1, 'gamma': 0.512093058299281, 'importance_type': 'cover',
'learning_rate': 0.3486659872917294, 'max_delta_step': 6, 'max_depth': 6,
'min_child_weight': 9, 'n_estimators': 100, 'random_state': 42, 'reg_alpha':
0.3975720210875223, 'reg_lambda': 0.5177513505274801, 'scale_pos_weight':
0.837710105907328, 'subsample': 0.6756901170392807}
XGBClassifier(base_score=0.5, booster='dart', colsample_bylevel=1,
              colsample_bynode=0, colsample_bytree=1, gamma=0.512093058299281,
              learning_rate=0.3486659872917294, max_delta_step=6, max_depth=6,
              min_child_weight=9, missing=None, n_estimators=100, n_jobs=1,
              nthread=None, objective='binary:logistic', random_state=42,
              reg_alpha=0.3975720210875223, reg_lambda=0.5177513505274801,
              scale_pos_weight=0.837710105907328, seed=None, silent=None,
              subsample=0.6756901170392807, verbosity=1)
```

Create a XGBoost classifier

[101]:

```
model=XGBClassifier(base_score=0.5, booster='dart', colsample_bylevel=1,
              colsample_bynode=0, colsample_bytree=1, gamma=0.512093058299281,
              learning_rate=0.3486659872917294, max_delta_step=6, max_depth=6,
              min_child_weight=9, missing=None, n_estimators=100, n_jobs=1,
              nthread=None, objective='binary:logistic', random_state=42,
              reg_alpha=0.3975720210875223, reg_lambda=0.5177513505274801,
              scale_pos_weight=0.837710105907328, seed=None, silent=None,
              subsample=0.6756901170392807, verbosity=1)
```

Testing using K Fold

[102]:

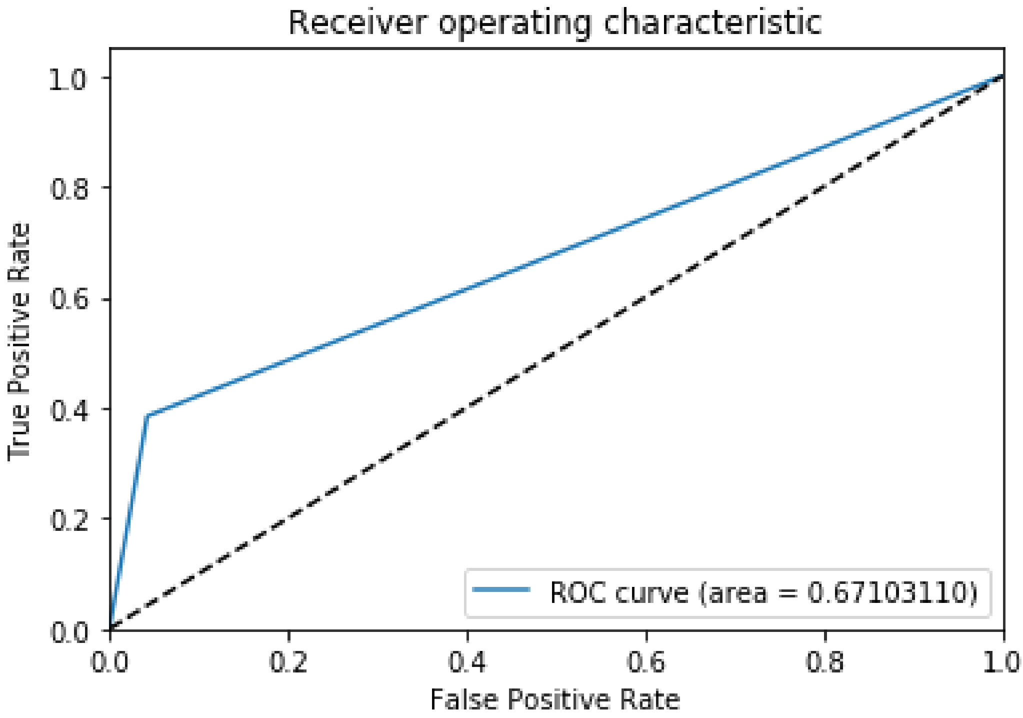
```
accuracy_XGB_KF=[]
roc_auc_XGB_KF=[]
```

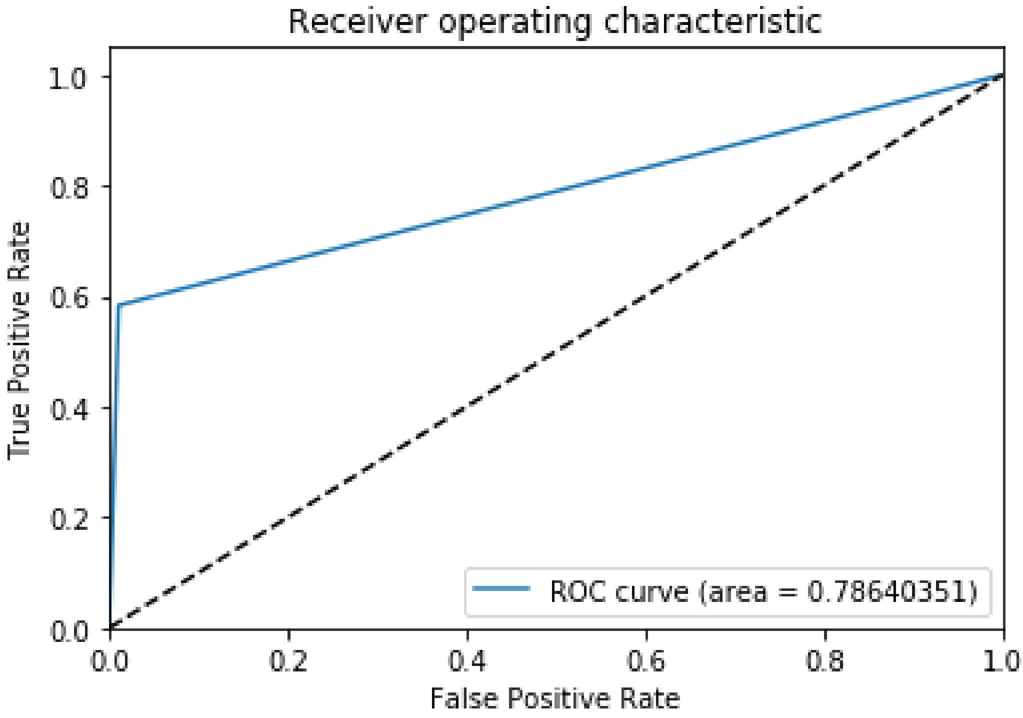
[103]:

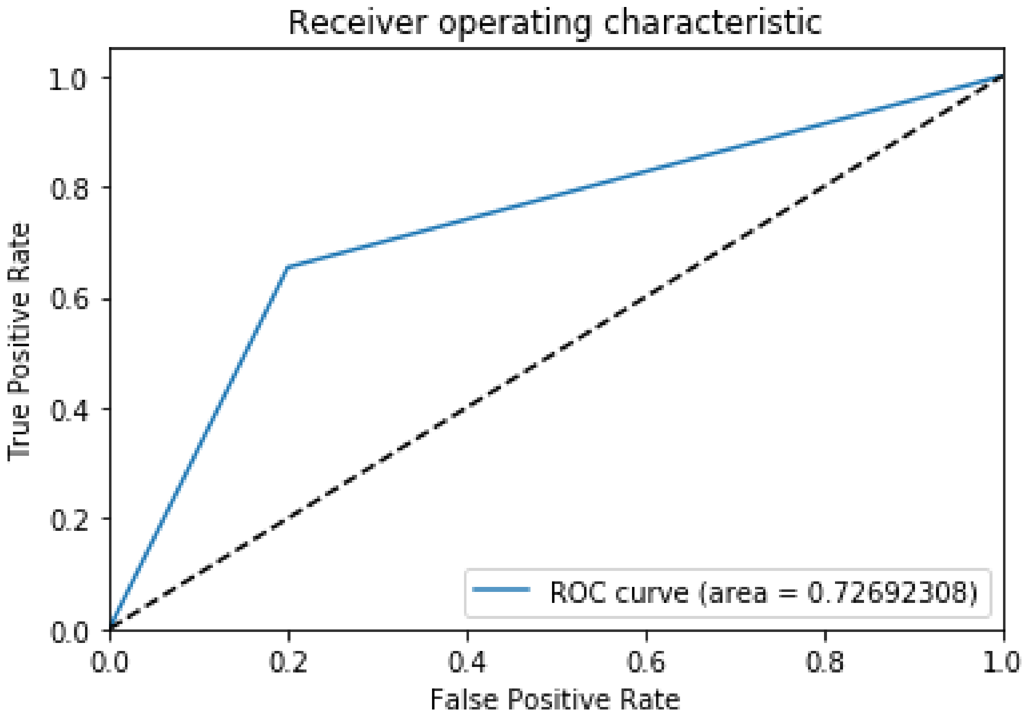
```
kf_XGB = KFold(n_splits=10,random_state=42)
```

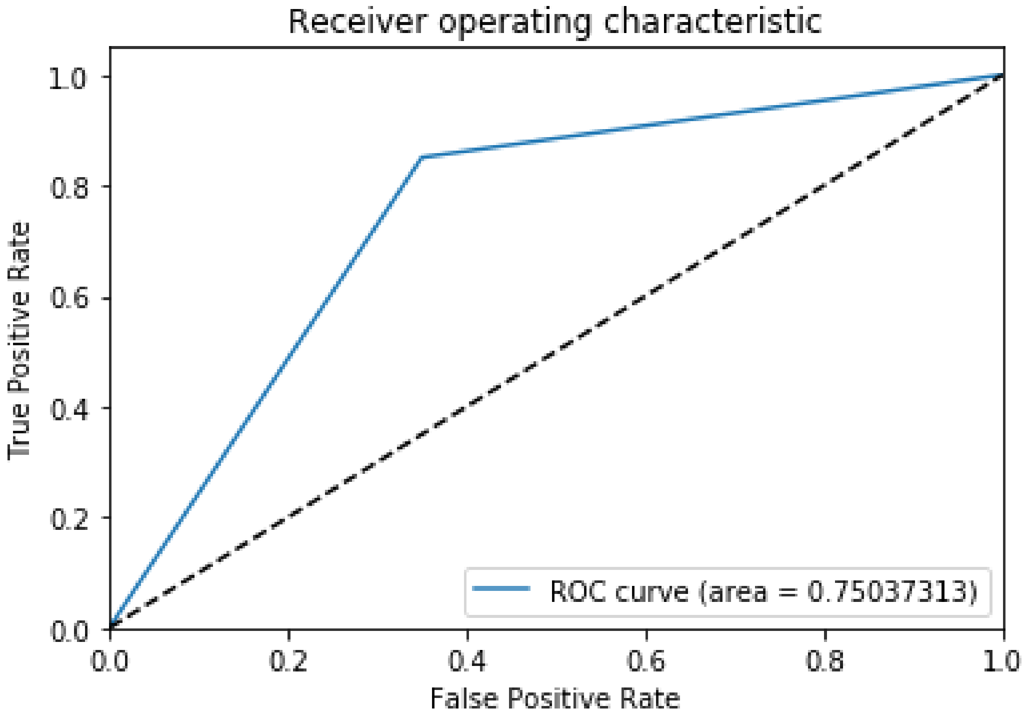
[104]:

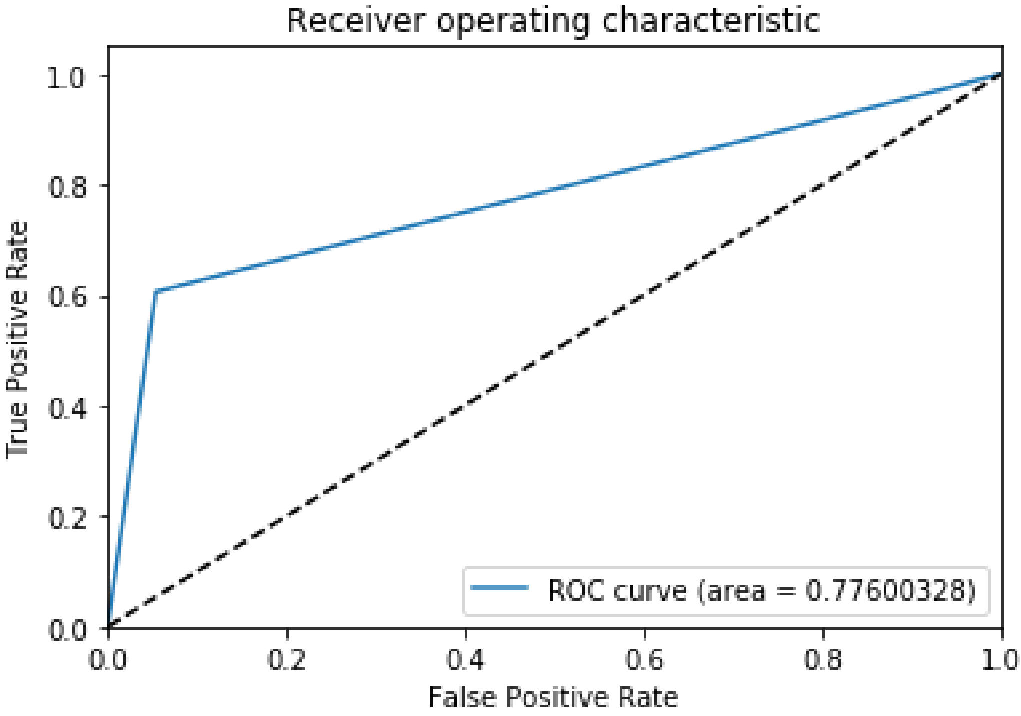
```
for train_index,test_index in kf_XGB.split(X_XGB_KF,y_XGB_KF):
    X_train_XGB_KF,X_test_XGB_KF,y_train_XGB_KF,y_test_XGB_KF = X_XGB_KF.
 ↪iloc[train_index],X_XGB_KF.iloc[test_index],y_XGB_KF.
 ↪iloc[train_index],y_XGB_KF.iloc[test_index]

    model.fit(X_train_XGB_KF,y_train_XGB_KF)
    y_pred = model.predict(X_test_XGB_KF)
    score=accuracy_score(y_pred,y_test_XGB_KF)
    accuracy_XGB_KF.append(score)
    roc_auc_XGB_KF.append(roc_auc_score(y_test_XGB_KF,y_pred))
    plot_roc_auc(y_test_XGB_KF,y_pred)
```

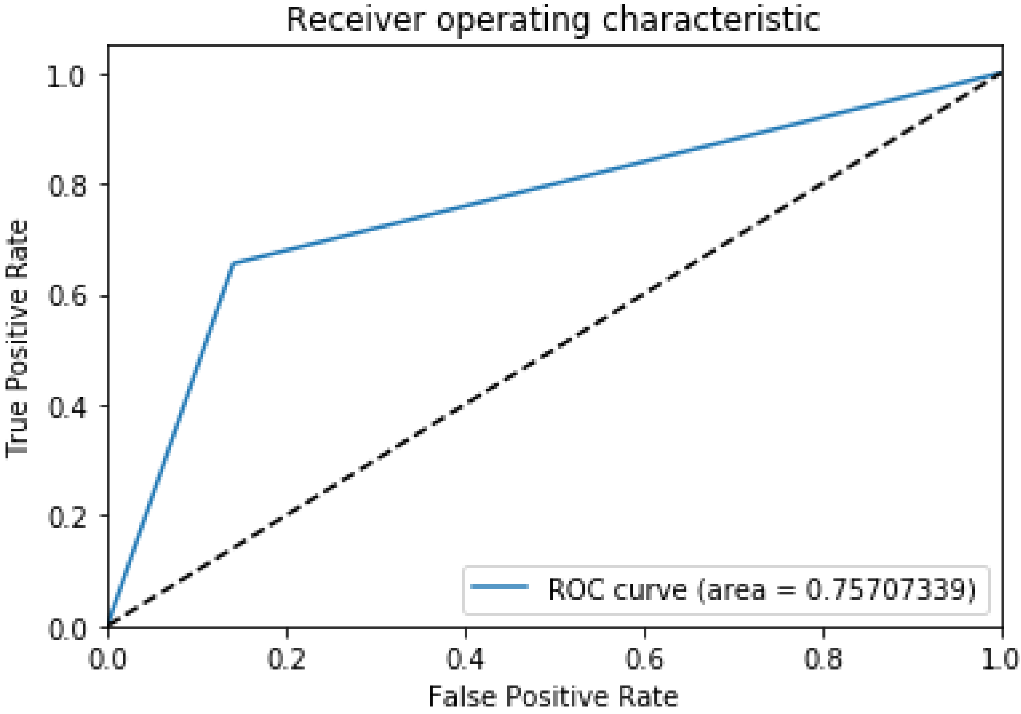

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.67103110)

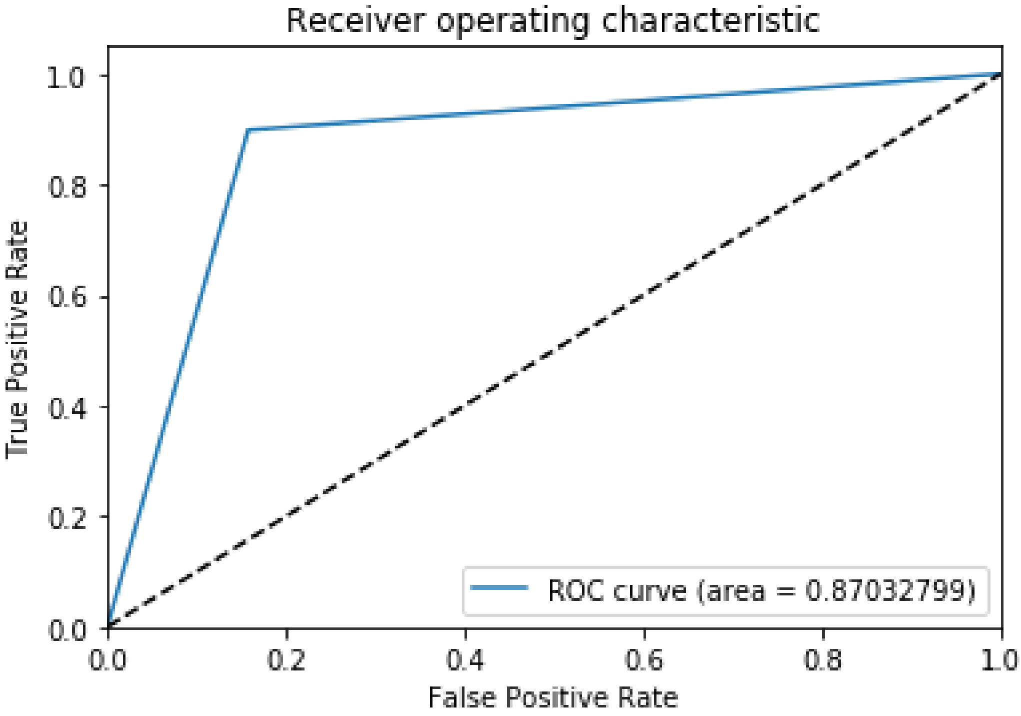

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.78640351)

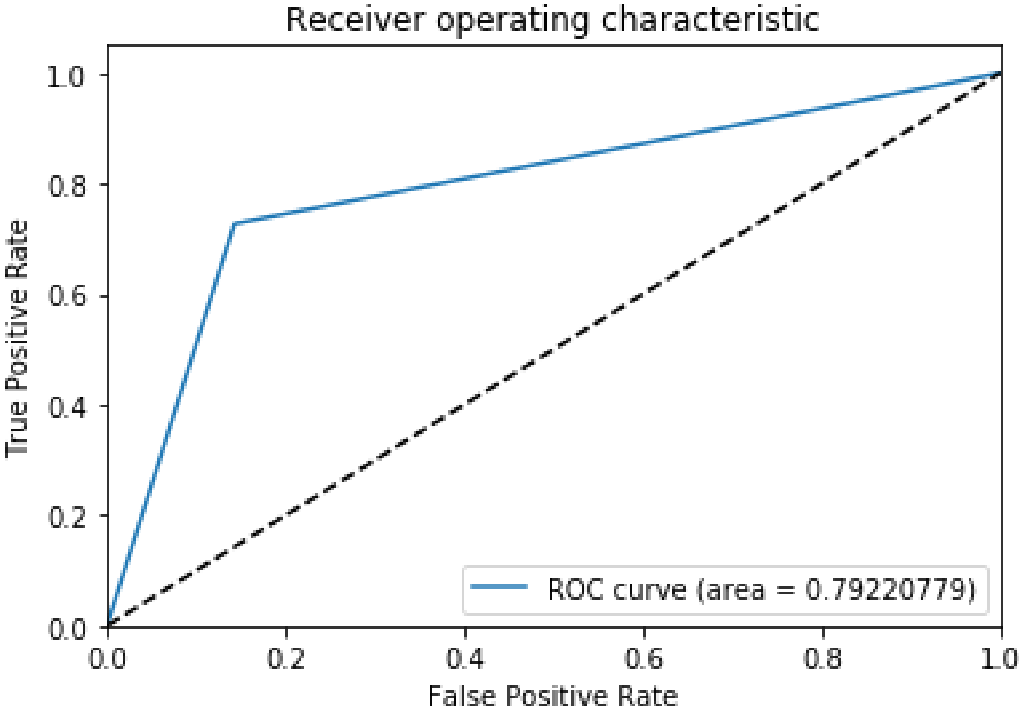

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.72692308)

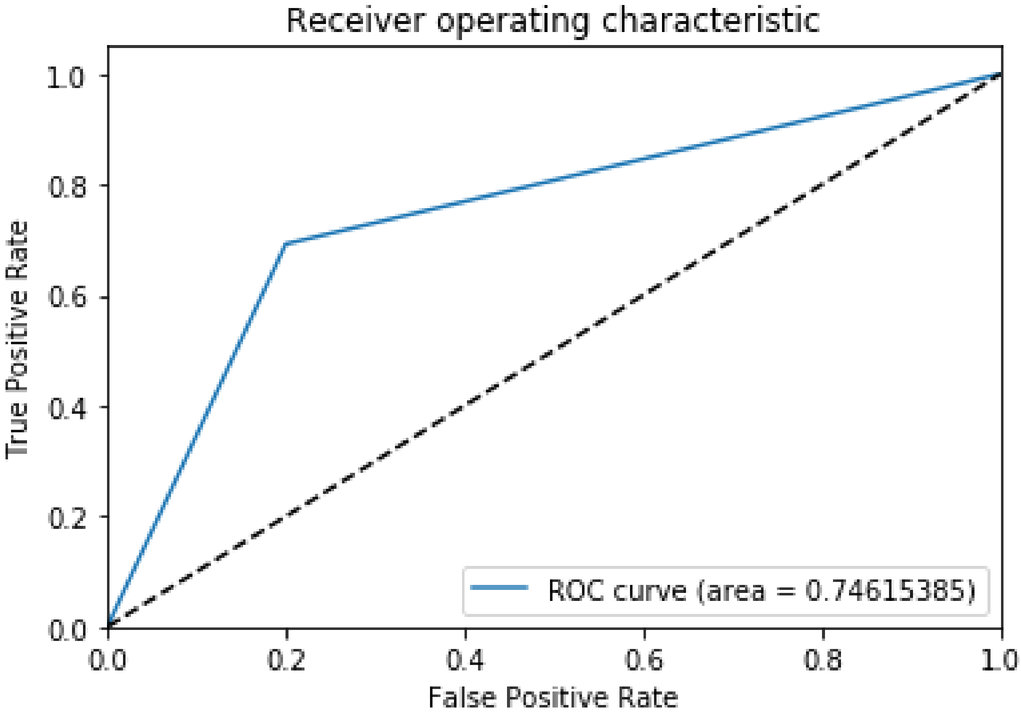

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.75037313)

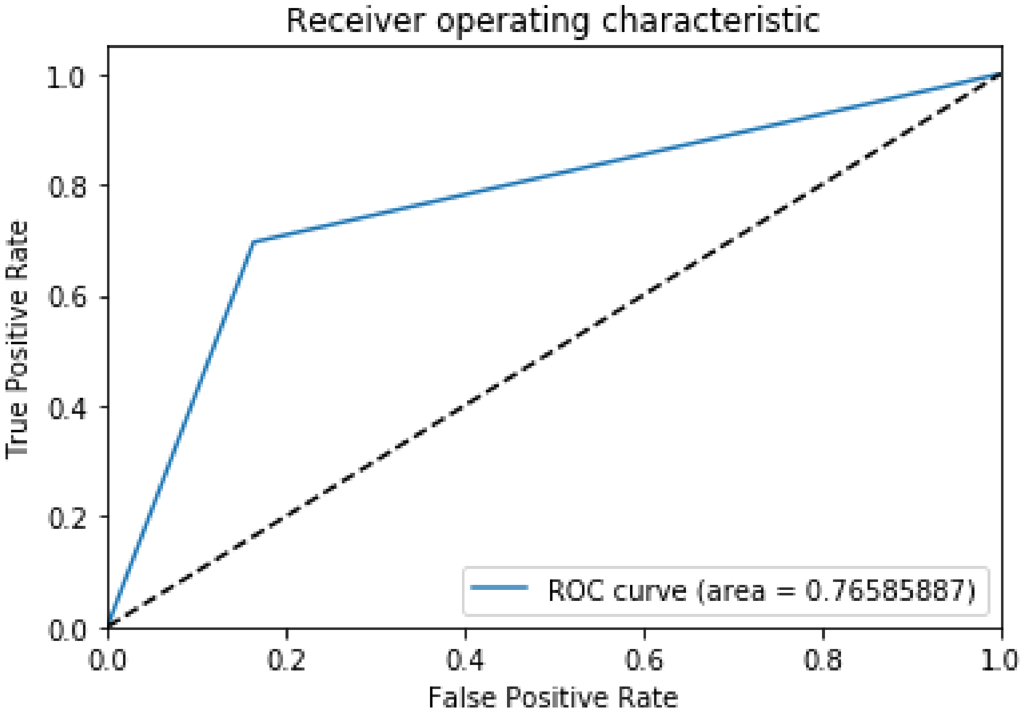

Receiver operating characteristic
1.0
0.8
0.6
0.4
0.2
0.0
True Positive Rate
ROC curve (area = 0.77600328)
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate


Receiver operating characteristic
1.0
0.8
0.6
0.4
0.2
0.0
True Positive Rate
ROC curve (area = 0.75707339)
0.0
0.2
0.4
0.6
0.8
1.0
False Positive Rate


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.87032799)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.79220779)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.74615385)

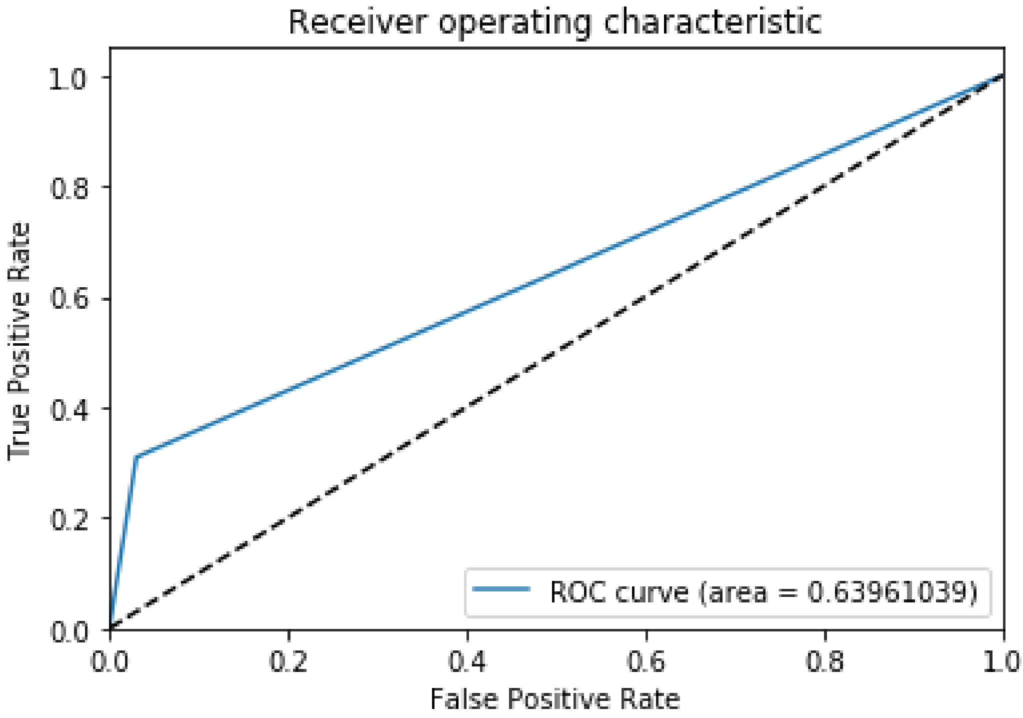

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.76585887)

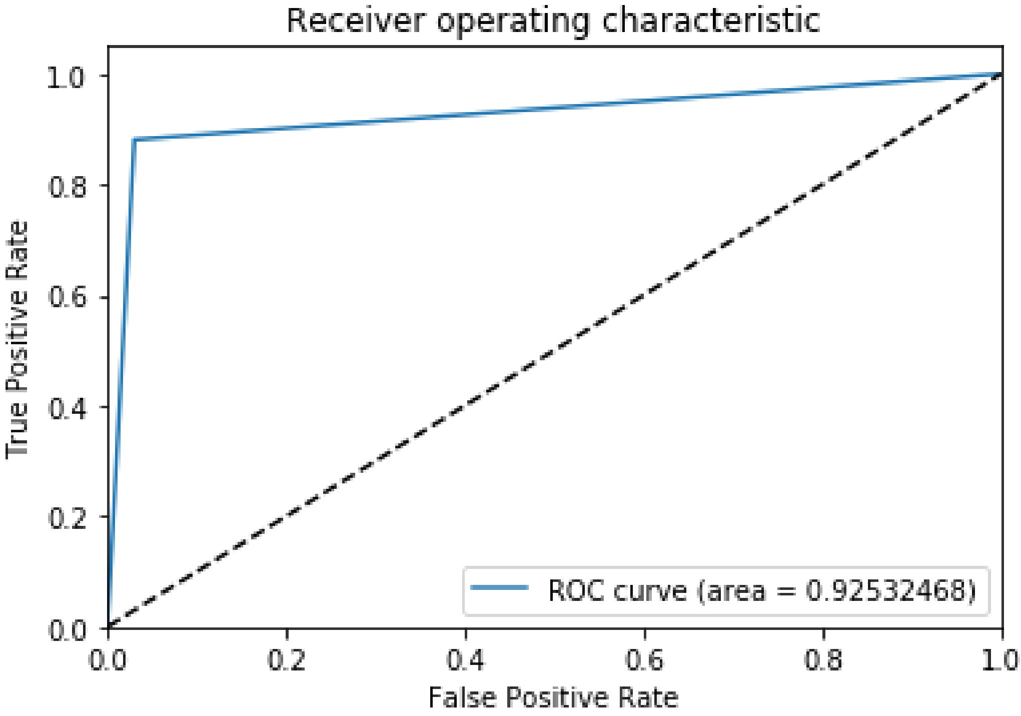
Testing using Stratified K Fold

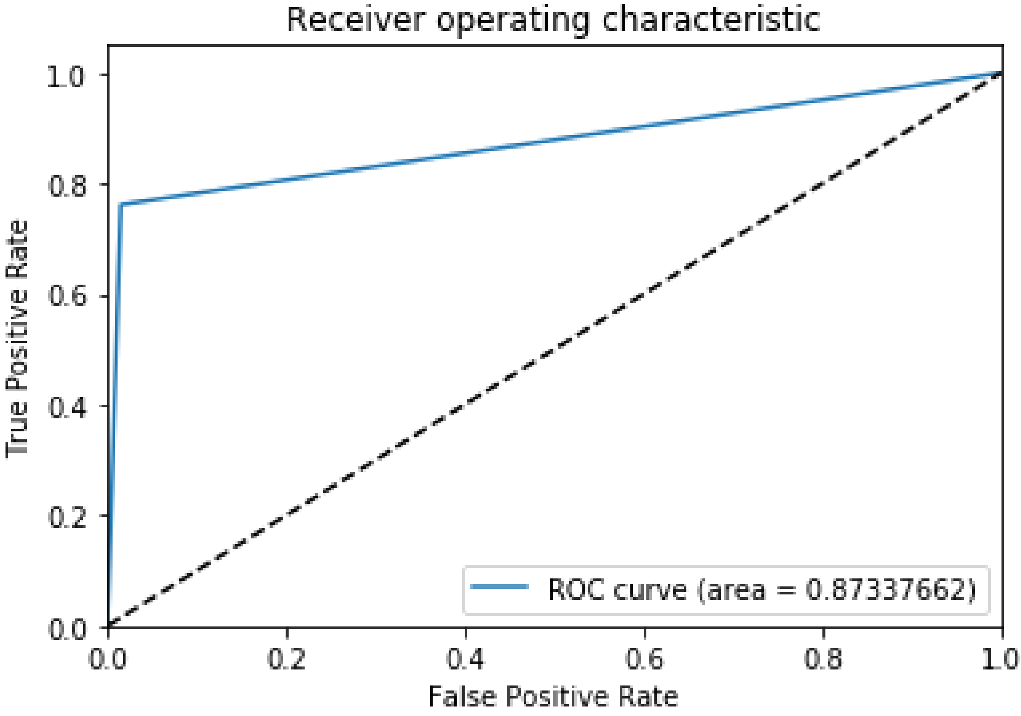
```
[105]: accuracy_XGB_SKF=[]
       roc_auc_XGB_SKF=[]
```

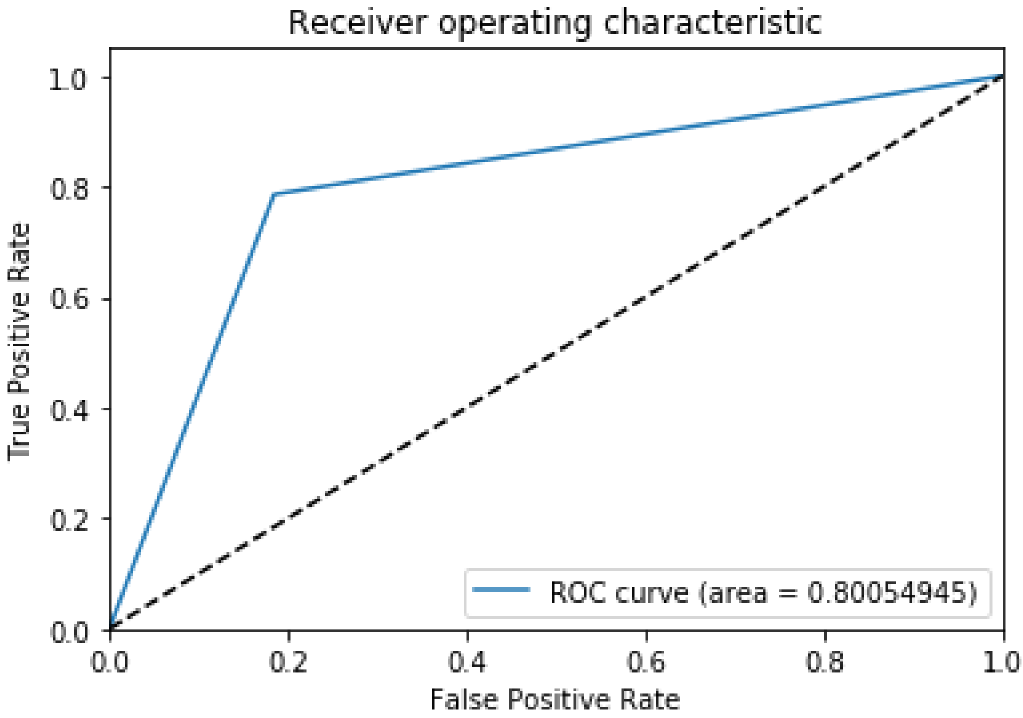
```
[106]: skf_XGB = StratifiedKFold(n_splits=10,random_state=42)
```

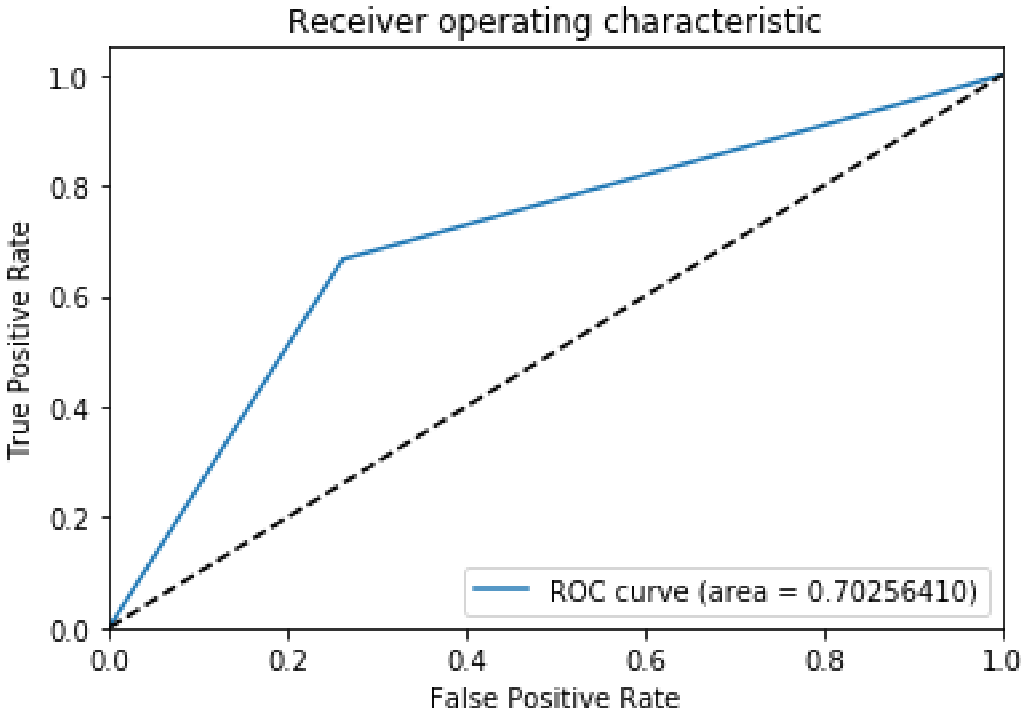
```
[107]: for train_index,test_index in skf_XGB.split(X_XGB_SKF,y_XGB_SKF):
           X_train_XGB_SKF,X_test_XGB_SKF,y_train_XGB_SKF,y_test_XGB_SKF = X_XGB_SKF.
        ↪iloc[train_index],X_XGB_SKF.iloc[test_index],y_XGB_SKF.
        ↪iloc[train_index],y_XGB_SKF.iloc[test_index]

           model.fit(X_train_XGB_SKF,y_train_XGB_SKF)
           y_pred = model.predict(X_test_XGB_SKF)
           score=accuracy_score(y_pred,y_test_XGB_SKF)
           accuracy_XGB_SKF.append(score)
           roc_auc_XGB_SKF.append(roc_auc_score(y_test_XGB_SKF,y_pred))
           plot_roc_auc(y_test_XGB_SKF,y_pred)
```

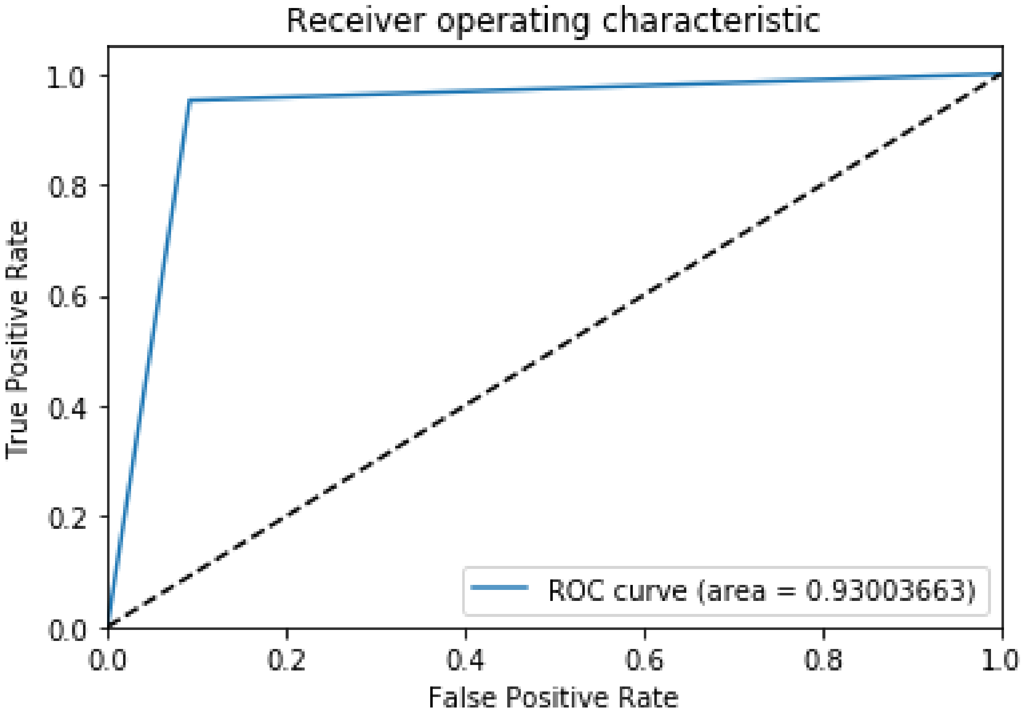


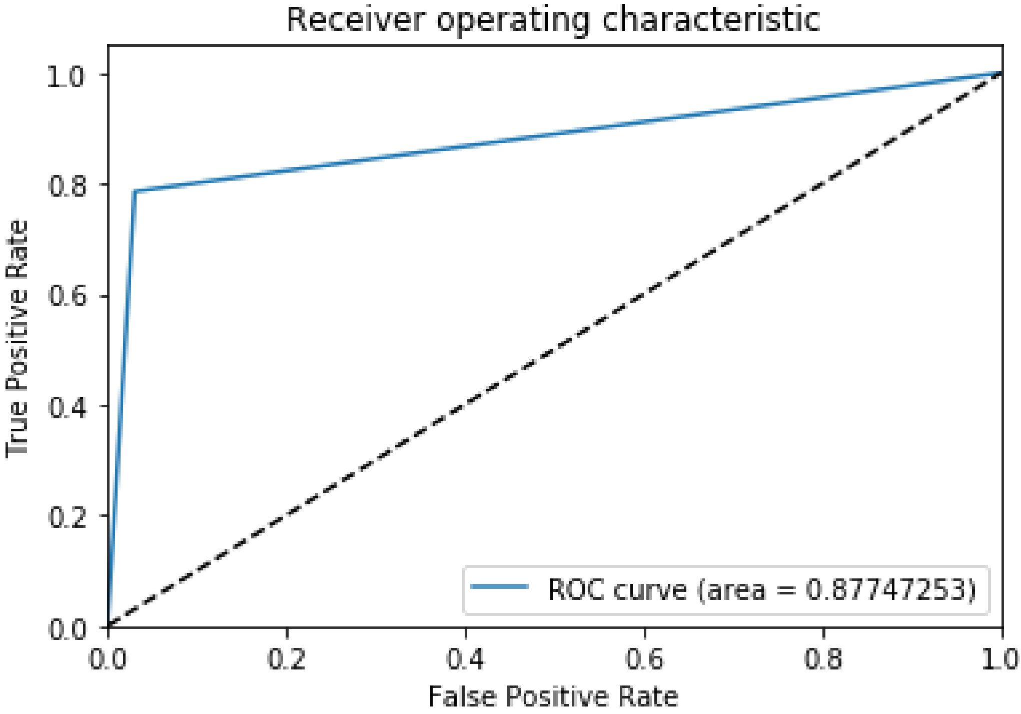

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.92532468)

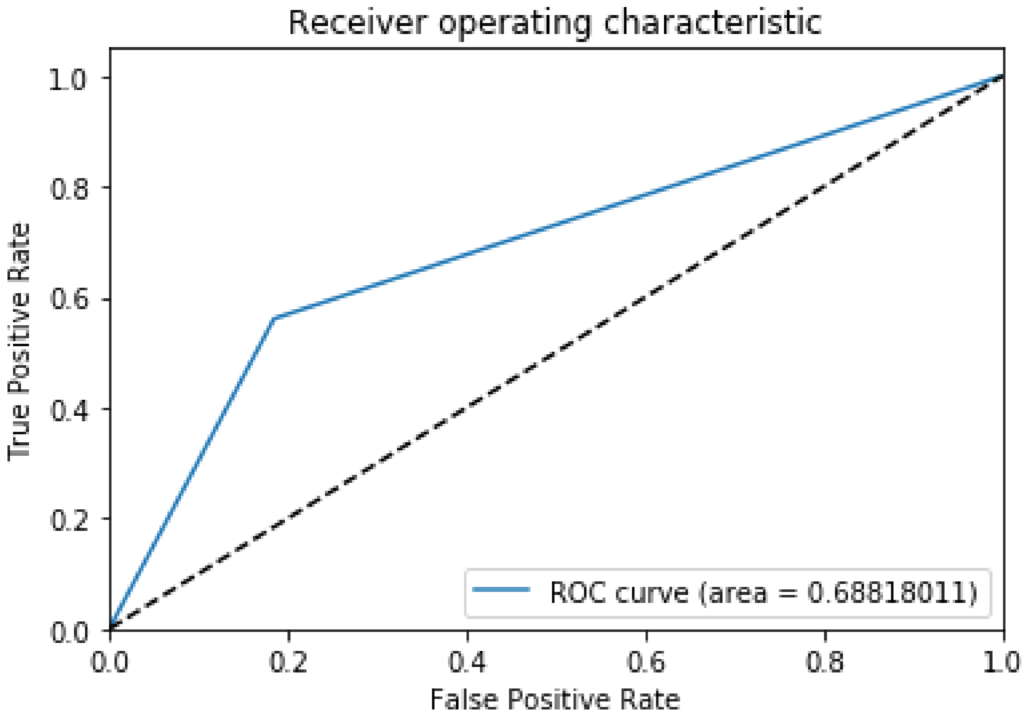

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.87337662)

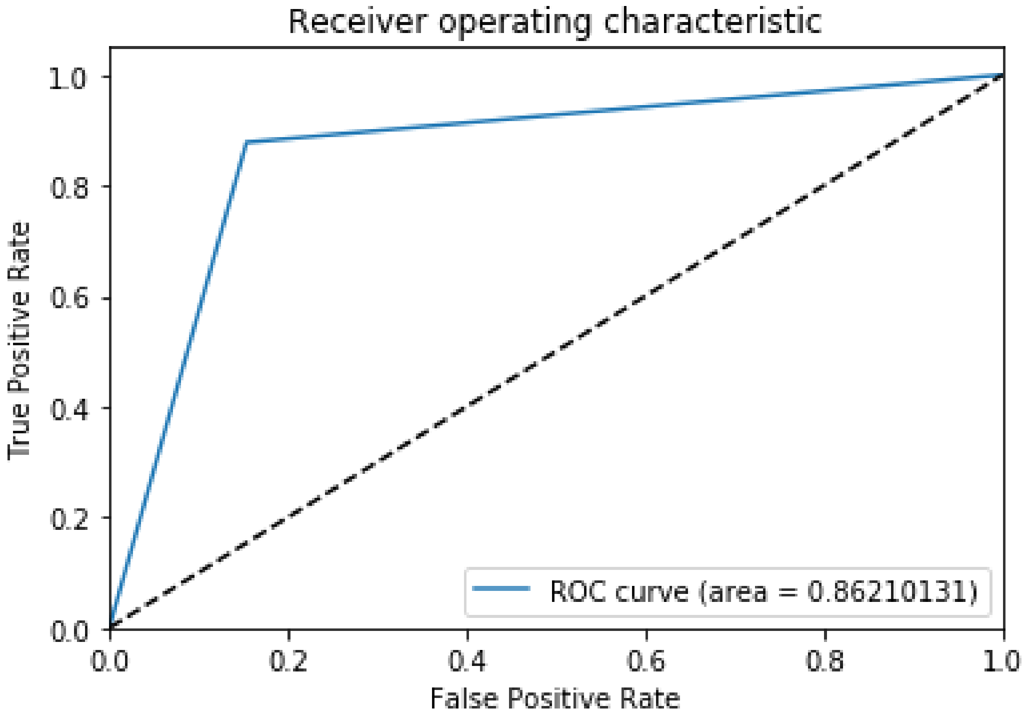

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.80054945)

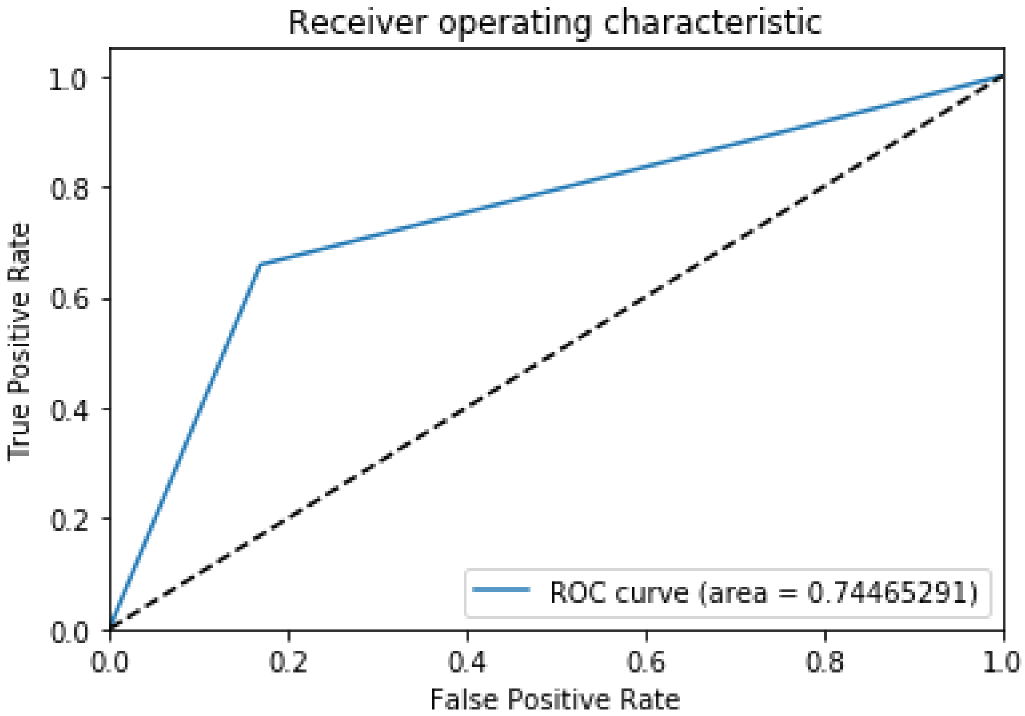

Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.70256410)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.93003663)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.87747253)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.68818011)


Receiver operating characteristic
True Positive Rate
False Positive Rate
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0
ROC curve (area = 0.86210131)



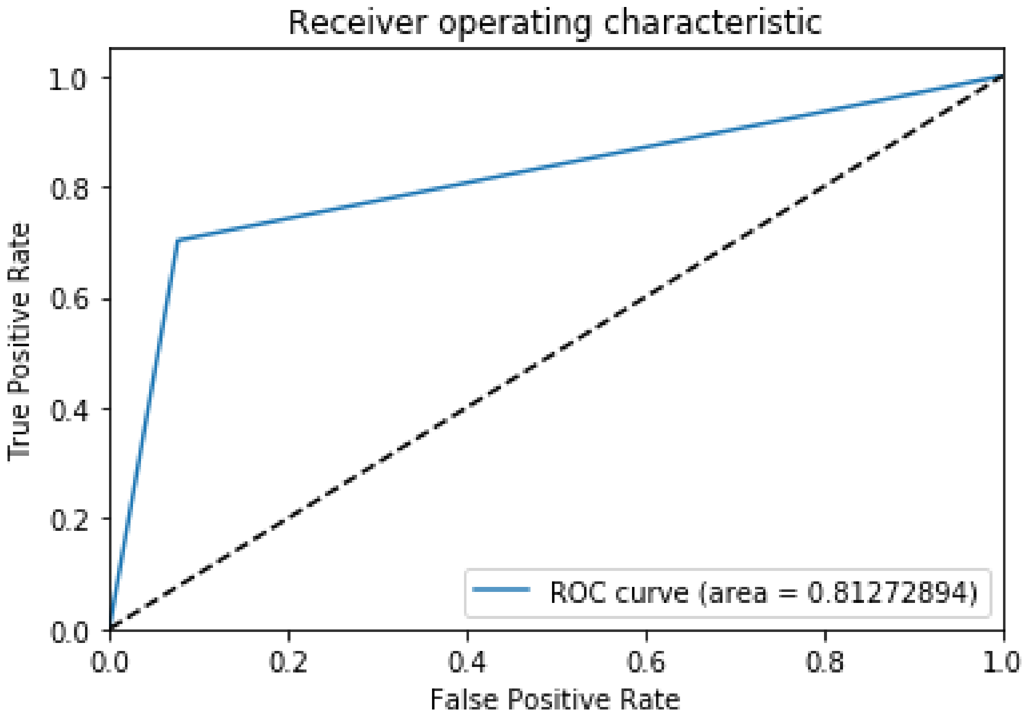
Train using train_test_split

[108]:
```
X_train_XGB, X_test_XGB, y_train_XGB, y_test_XGB = X_train, X_test, y_train,␣
 ↪y_test
model.fit(X_train_XGB,y_train_XGB)
```

[108]:
```
XGBClassifier(base_score=0.5, booster='dart', colsample_bylevel=1,
              colsample_bynode=0, colsample_bytree=1, gamma=0.512093058299281,
              learning_rate=0.3486659872917294, max_delta_step=6, max_depth=6,
              min_child_weight=9, missing=None, n_estimators=100, n_jobs=1,
              nthread=None, objective='binary:logistic', random_state=42,
              reg_alpha=0.3975720210875223, reg_lambda=0.5177513505274801,
              scale_pos_weight=0.837710105907328, seed=None, silent=None,
              subsample=0.6756901170392807, verbosity=1)
```

Test the classifier

[109]:
```
y_pred = model.predict(X_test_XGB)
plot_roc_auc(y_test_XGB,y_pred)
```



Evaluate the results

```
[110]: print(np.array(accuracy_XGB_KF).mean()) #k fold accuracy
```

```
0.8186915887850468
```

```
[111]: print(np.array(roc_auc_XGB_KF).mean()) #k fold roc auc
```

```
0.7642355985074578
```

```
[112]: print(np.array(accuracy_XGB_SKF).mean()) #stratified k fold
```

```
0.8222367535936572
```

```
[113]: print(np.array(roc_auc_XGB_SKF).mean()) #stratified k fold roc auc
```

```
0.8043868732893124
```

```
[114]: print(accuracy_score(y_pred,y_test_XGB)) #train test split
```

```
0.8364485981308412
```

```
[115]: print(np.array(cross_val_score(model,X_XGB_CV,y_XGB_CV,cv=10)).mean()) #cross␣
        ↪val
```

```
0.8222367535936572
```

Show other scores from train_test_split

[116]:
```
print_scores(model.__class__.__name__, y_test_XGB, y_pred)
```

```
Model: XGBClassifier
========================================================
*Accuracy score: 0.8364485981308412
--------------------------------------------------------
Classification report:
              precision    recall  f1-score   support

           0       0.83      0.92      0.87       130
           1       0.86      0.70      0.77        84

    accuracy                           0.84       214
   macro avg       0.84      0.81      0.82       214
weighted avg       0.84      0.84      0.83       214

--------------------------------------------------------
Confusion matrix:
[[120  10]
 [ 25  59]]
--------------------------------------------------------
Precision score: 0.855072463768116
--------------------------------------------------------
Recall score: 0.7023809523809523
--------------------------------------------------------
F1 score: 0.7712418300653594
--------------------------------------------------------
Log loss score: 5.648902662598953
--------------------------------------------------------
ROC-AUC score: 0.8127289377289377
--------------------------------------------------------
Sensitivity score: 0.9230769230769231
--------------------------------------------------------
Specificity score: 0.7023809523809523
```

[ ]:
```

```