Social network Graph Link Prediction - Facebook Challenge

In [0]:

```
#Importing Libraries
# please do go through this python notebook:
import warnings
warnings.filterwarnings("ignore")

import csv
import pandas as pd#pandas to create small dataframes
import datetime #Convert to unix time
import time #Convert to unix time
# if numpy is not installed already : pip3 install numpy
import numpy as np#Do aritmetic operations on arrays
# matplotlib: used to plot graphs
import matplotlib
import matplotlib.pylab as plt
import seaborn as sns#Plots
from matplotlib import rcParams#Size of plots
from sklearn.cluster import MiniBatchKMeans, KMeans#Clustering
import math
import pickle
import os
# to install xgboost: pip3 install xgboost
import xgboost as xgb

import warnings
import networkx as nx
import pdb
import pickle
from pandas import HDFStore,DataFrame
from pandas import read_hdf
from scipy.sparse.linalg import svds, eigs
import gc
from tqdm import tqdm
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import f1_score
```

In [2]:

```
# Code to read csv file into Colaboratory:

!pip install -U -q PyDrive
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from google.colab import auth
from oauth2client.client import GoogleCredentials

# Authenticate and create the PyDrive client.
auth.authenticate_user()
gauth = GoogleAuth()
gauth.credentials = GoogleCredentials.get_application_default()
drive = GoogleDrive(gauth)
```

```
    100% |████████████████████████████████| 993kB 23.1MB/s
  Building wheel for PyDrive (setup.py) ... done
```

In [0]:

```
link = 'https://drive.google.com/open?id=1O-CCFWFSQVGNKHlN0NXDG1dSc-YJVzDj'
```

In [15]:

```
fluff, id = link.split('=')

print (id)
```

```
1O-CCFWFSQVGNKHlN0NXDG1dSc-YJVzDj
```

In [0]:

```
downloaded = drive.CreateFile({'id':id})
downloaded.GetContentFile('storage_sample_stage5.h5')
#df_final_train = pd.read_csv('train_pos_after_eda.csv')
```

In [0]:

```
#reading
from pandas import read_hdf
df_final_train = read_hdf('storage_sample_stage5.h5', 'train_df',mode='r')
df_final_test = read_hdf('storage_sample_stage5.h5', 'test_df',mode='r')
```

In [18]:

```
df_final_train.columns
```

Out[18]:

```
Index(['source_node', 'destination_node', 'indicator_link',
       'jaccard_followers', 'jaccard_followees', 'cosine_followers',
       'cosine_followees', 'num_followers_s', 'num_followees_s',
       'num_followees_d', 'inter_followers', 'inter_followees', 'adar_inde
x',
       'follows_back', 'same_comp', 'shortest_path', 'pref_path', 'weight_
in',
       'weight_out', 'weight_f1', 'weight_f2', 'weight_f3', 'weight_f4',
       'page_rank_s', 'page_rank_d', 'katz_s', 'katz_d', 'hubs_s', 'hubs_
d',
       'authorities_s', 'authorities_d', 'svd_u_s_1', 'svd_u_s_2', 'svd_u_
s_3',
       'svd_u_s_4', 'svd_u_s_5', 'svd_u_s_6', 'svd_u_d_1', 'svd_u_d_2',
       'svd_u_d_3', 'svd_u_d_4', 'svd_u_d_5', 'svd_u_d_6', 'svd_v_s_1',
       'svd_v_s_2', 'svd_v_s_3', 'svd_v_s_4', 'svd_v_s_5', 'svd_v_s_6',
       'svd_v_d_1', 'svd_v_d_2', 'svd_v_d_3', 'svd_v_d_4', 'svd_v_d_5',
       'svd_v_d_6', 'svd_dot_s1d1', 'svd_dot_s2d2', 'svd_dot_s3d3',
       'svd_dot_s4d4', 'svd_dot_s5d5', 'svd_dot_s6d6'],
      dtype='object')
```

In [0]:

```
y_train = df_final_train.indicator_link
y_test = df_final_test.indicator_link
```

In [0]:

```
df_final_train.drop(['source_node', 'destination_node','indicator_link'],axis=1,inplace
=True)
df_final_test.drop(['source_node', 'destination_node','indicator_link'],axis=1,inplace=
True)
```

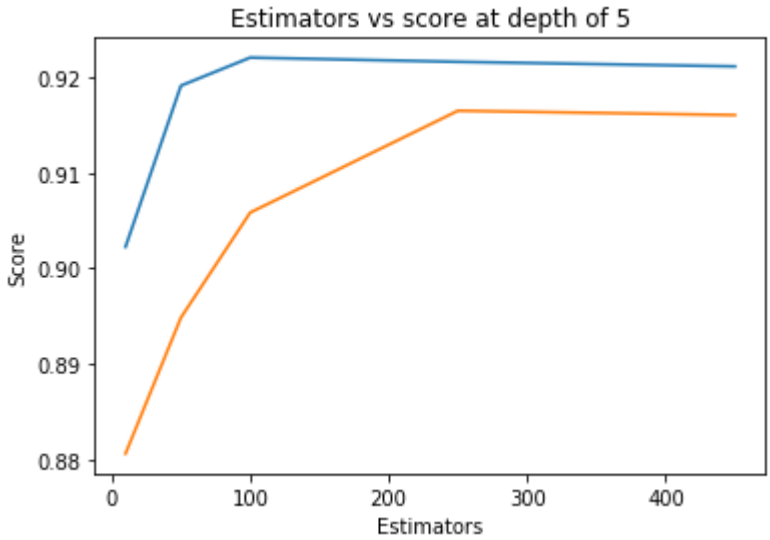
In [0]:

```
estimators = [10,50,100,250,450]
train_scores = []
test_scores = []
for i in estimators:
    clf = RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=5, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=52, min_samples_split=120,
            min_weight_fraction_leaf=0.0, n_estimators=i, n_jobs=-1,random_state=25,ver
bose=0,warm_start=False)
    clf.fit(df_final_train,y_train)
    train_sc = f1_score(y_train,clf.predict(df_final_train))
    test_sc = f1_score(y_test,clf.predict(df_final_test))
    test_scores.append(test_sc)
    train_scores.append(train_sc)
    print('Estimators = ',i,'Train Score',train_sc,'test Score',test_sc)
plt.plot(estimators,train_scores,label='Train Score')
plt.plot(estimators,test_scores,label='Test Score')
plt.xlabel('Estimators')
plt.ylabel('Score')
plt.title('Estimators vs score at depth of 5')
```

```
Estimators =  10 Train Score 0.9022369511184755 test Score 0.8805802121671
358
Estimators =  50 Train Score 0.9191187249994764 test Score 0.8948247078464
107
Estimators =  100 Train Score 0.9220590540893648 test Score 0.905826932054
4922
Estimators =  250 Train Score 0.9216165924439148 test Score 0.916493525572
4149
Estimators =  450 Train Score 0.9211405193287134 test Score 0.916041413421
6373
```

Out[0]:

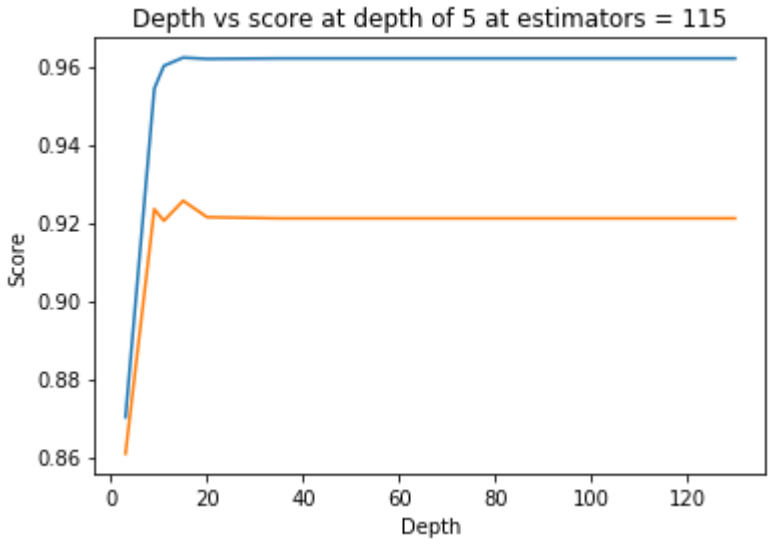
```
Text(0.5,1,'Estimators vs score at depth of 5')
```



In [0]:

```
depths = [3,9,11,15,20,35,50,70,130]
train_scores = []
test_scores = []
for i in depths:
    clf = RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=i, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=52, min_samples_split=120,
            min_weight_fraction_leaf=0.0, n_estimators=115, n_jobs=-1,random_state=25,v
erbose=0,warm_start=False)
    clf.fit(df_final_train,y_train)
    train_sc = f1_score(y_train,clf.predict(df_final_train))
    test_sc = f1_score(y_test,clf.predict(df_final_test))
    test_scores.append(test_sc)
    train_scores.append(train_sc)
    print('depth = ',i,'Train Score',train_sc,'test Score',test_sc)
plt.plot(depths,train_scores,label='Train Score')
plt.plot(depths,test_scores,label='Test Score')
plt.xlabel('Depth')
plt.ylabel('Score')
plt.title('Depth vs score at depth of 5 at estimators = 115')
plt.show()
```

```
depth =  3 Train Score 0.870159259692105 test Score 0.8608207676490747
depth =  9 Train Score 0.9542464940723996 test Score 0.9234302570585756
depth =  11 Train Score 0.9600903154939892 test Score 0.9204182951304531
depth =  15 Train Score 0.9621916474870474 test Score 0.9255580521198632
depth =  20 Train Score 0.9618576492935286 test Score 0.921354958607873
depth =  35 Train Score 0.9619829004285047 test Score 0.9210559662090814
depth =  50 Train Score 0.9619829004285047 test Score 0.9210559662090814
depth =  70 Train Score 0.9619829004285047 test Score 0.9210559662090814
depth =  130 Train Score 0.9619829004285047 test Score 0.9210559662090814
```



In [0]:

```
from sklearn.metrics import f1_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import f1_score
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint as sp_randint
from scipy.stats import uniform

param_dist = {"n_estimators":sp_randint(105,125),
              "max_depth": sp_randint(10,15),
              "min_samples_split": sp_randint(110,190),
              "min_samples_leaf": sp_randint(25,65)}

clf = RandomForestClassifier(random_state=25,n_jobs=-1)

rf_random = RandomizedSearchCV(clf, param_distributions=param_dist,
                                    n_iter=5,cv=10,scoring='f1',random_state=25)

rf_random.fit(df_final_train,y_train)
print('mean test scores',rf_random.cv_results_['mean_test_score'])
print('mean train scores',rf_random.cv_results_['mean_train_score'])
```

```
mean test scores [0.96071901 0.96071897 0.9589363  0.96033063 0.96220968]
mean train scores [0.96119724 0.96116135 0.95928845 0.9608778  0.96289795]
```

In [0]:

```
print(rf_random.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gin
i',
            max_depth=14, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=28, min_samples_split=111,
            min_weight_fraction_leaf=0.0, n_estimators=121, n_jobs=-1,
            oob_score=False, random_state=25, verbose=0, warm_start=False)
```

In [0]:

```
clf = RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=14, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=28, min_samples_split=111,
            min_weight_fraction_leaf=0.0, n_estimators=121, n_jobs=-1,
            oob_score=False, random_state=25, verbose=0, warm_start=False)
```

In [0]:

```
clf.fit(df_final_train,y_train)
y_train_pred = clf.predict(df_final_train)
y_test_pred = clf.predict(df_final_test)
```

In [0]:

```
from sklearn.metrics import f1_score
print('Train f1 score',f1_score(y_train,y_train_pred))
print('Test f1 score',f1_score(y_test,y_test_pred))
```

```
Train f1 score 0.962873399715505
Test f1 score 0.9226444604134082
```

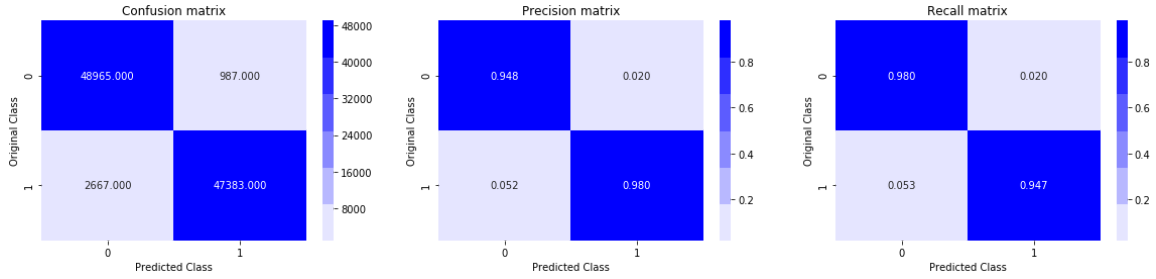
In [0]:

```
from sklearn.metrics import confusion_matrix
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)

    A =(((C.T)/(C.sum(axis=1))).T)

    B =(C/C.sum(axis=0))
    plt.figure(figsize=(20,4))

    labels = [0,1]
    # representing A in heatmap format
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=la
bels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Confusion matrix")

    plt.subplot(1, 3, 2)
    sns.heatmap(B, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=la
bels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Precision matrix")

    plt.subplot(1, 3, 3)
    # representing B in heatmap format
    sns.heatmap(A, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=la
bels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

    plt.show()
```

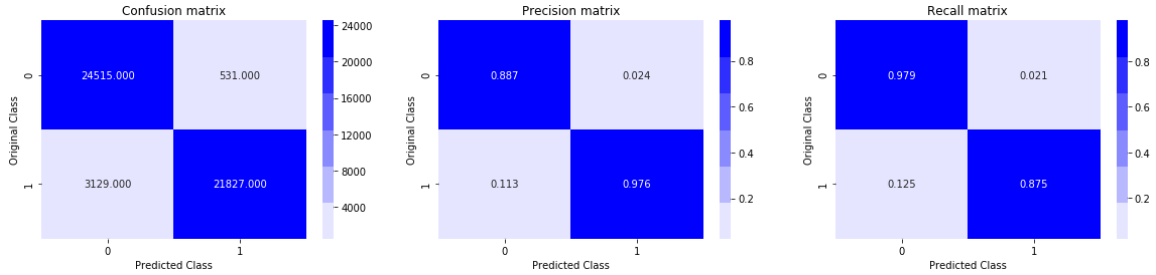
In [0]:

```
print('Train confusion_matrix')
plot_confusion_matrix(y_train,y_train_pred)
print('Test confusion_matrix')
plot_confusion_matrix(y_test,y_test_pred)
```

Train confusion_matrix

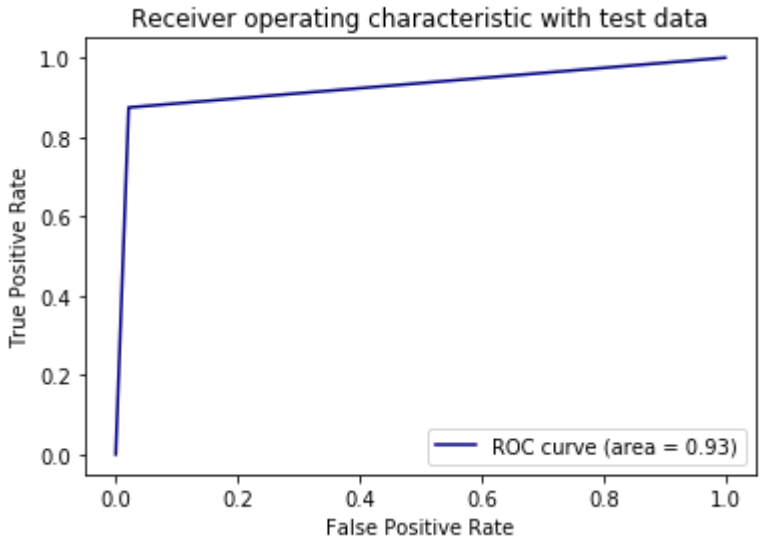


Test confusion_matrix



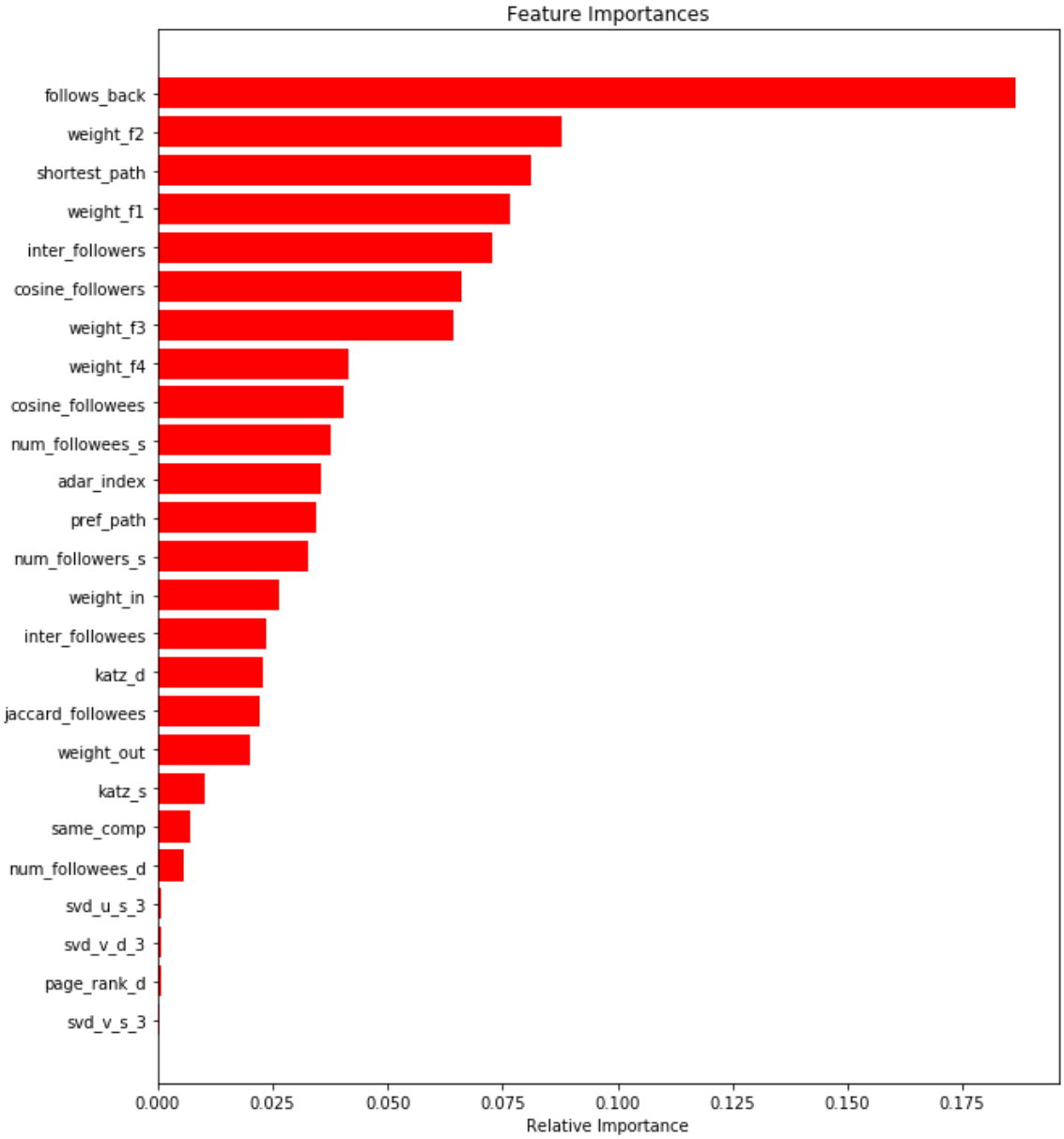
In [0]:

```
from sklearn.metrics import roc_curve, auc
fpr,tpr,ths = roc_curve(y_test,y_test_pred)
auc_sc = auc(fpr, tpr)
plt.plot(fpr, tpr, color='navy',label='ROC curve (area = %0.2f)' % auc_sc)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic with test data')
plt.legend()
plt.show()
```



In [0]:

```
features = df_final_train.columns
importances = clf.feature_importances_
indices = (np.argsort(importances))[-25:]
plt.figure(figsize=(10,12))
plt.title('Feature Importances')
plt.barh(range(len(indices)), importances[indices], color='r', align='center')
plt.yticks(range(len(indices)), [features[i] for i in indices])
plt.xlabel('Relative Importance')
plt.show()
```



XG Boost with RandomSearch:

In [25]:

```
from sklearn.metrics import f1_score
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import f1_score
from sklearn.model_selection import RandomizedSearchCV
from scipy.stats import randint as sp_randint
from scipy.stats import uniform
import xgboost as xgb

param_dist = {"n_estimators":sp_randint(105,125),
              "max_depth": sp_randint(10,15),
              "min_samples_split": sp_randint(110,190),
              "min_samples_leaf": sp_randint(25,65)}

clf = xgb.XGBClassifier(random_state=25,n_jobs=-1)

rf_random = RandomizedSearchCV(clf, param_distributions=param_dist,
                                    n_iter=5,cv=10,scoring='f1',random_state=25)

rf_random.fit(df_final_train,y_train)
print('mean test scores',rf_random.cv_results_['mean_test_score'])
print('mean train scores',rf_random.cv_results_['mean_train_score'])
```

```
mean test scores [0.98034644 0.98039348 0.98029039 0.98043961 0.98022609]
mean train scores [0.99984234 0.99734773 0.99472367 0.99867519 0.9999234 ]
```

In [26]:

```
print(rf_random.best_estimator_)
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
       max_depth=13, min_child_weight=1, min_samples_leaf=49,
       min_samples_split=165, missing=None, n_estimators=108, n_jobs=-1,
       nthread=None, objective='binary:logistic', random_state=25,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=True, subsample=1)
```

In [0]:

```
clf = xgb.XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
       max_depth=13, min_child_weight=1, min_samples_leaf=49,
       min_samples_split=165, missing=None, n_estimators=108, n_jobs=-1,
       nthread=None, objective='binary:logistic', random_state=25,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=True, subsample=1)
```

In [0]:

```
clf.fit(df_final_train,y_train)
y_train_pred = clf.predict(df_final_train)
y_test_pred = clf.predict(df_final_test)
```

In [29]:

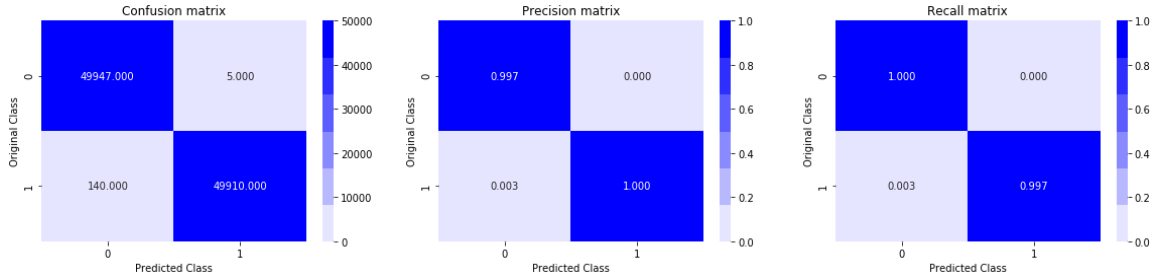
```
from sklearn.metrics import f1_score
print('Train f1 score',f1_score(y_train,y_train_pred))
print('Test f1 score',f1_score(y_test,y_test_pred))
```

```
Train f1 score 0.9985494923223127
Test f1 score 0.9267816189586341
```

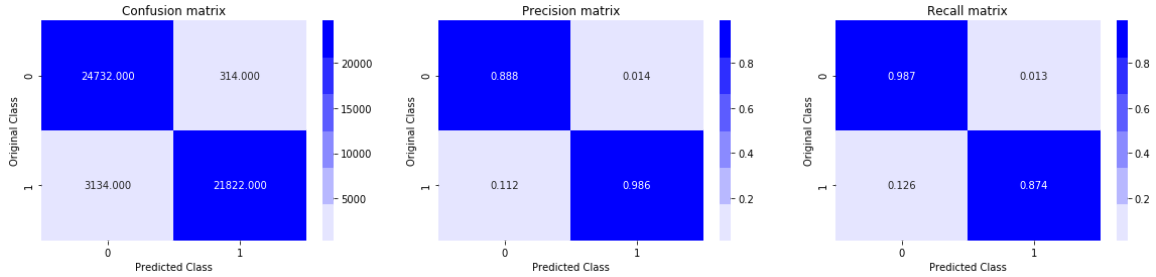
In [32]:

```
print('Train confusion_matrix')
plot_confusion_matrix(y_train,y_train_pred)
print('Test confusion_matrix')
plot_confusion_matrix(y_test,y_test_pred)
```

```
Train confusion_matrix
```

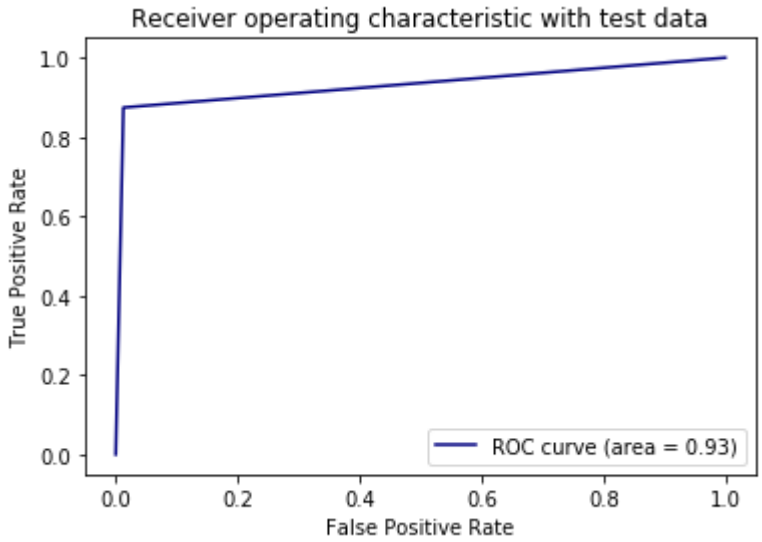



```
Test confusion_matrix
```



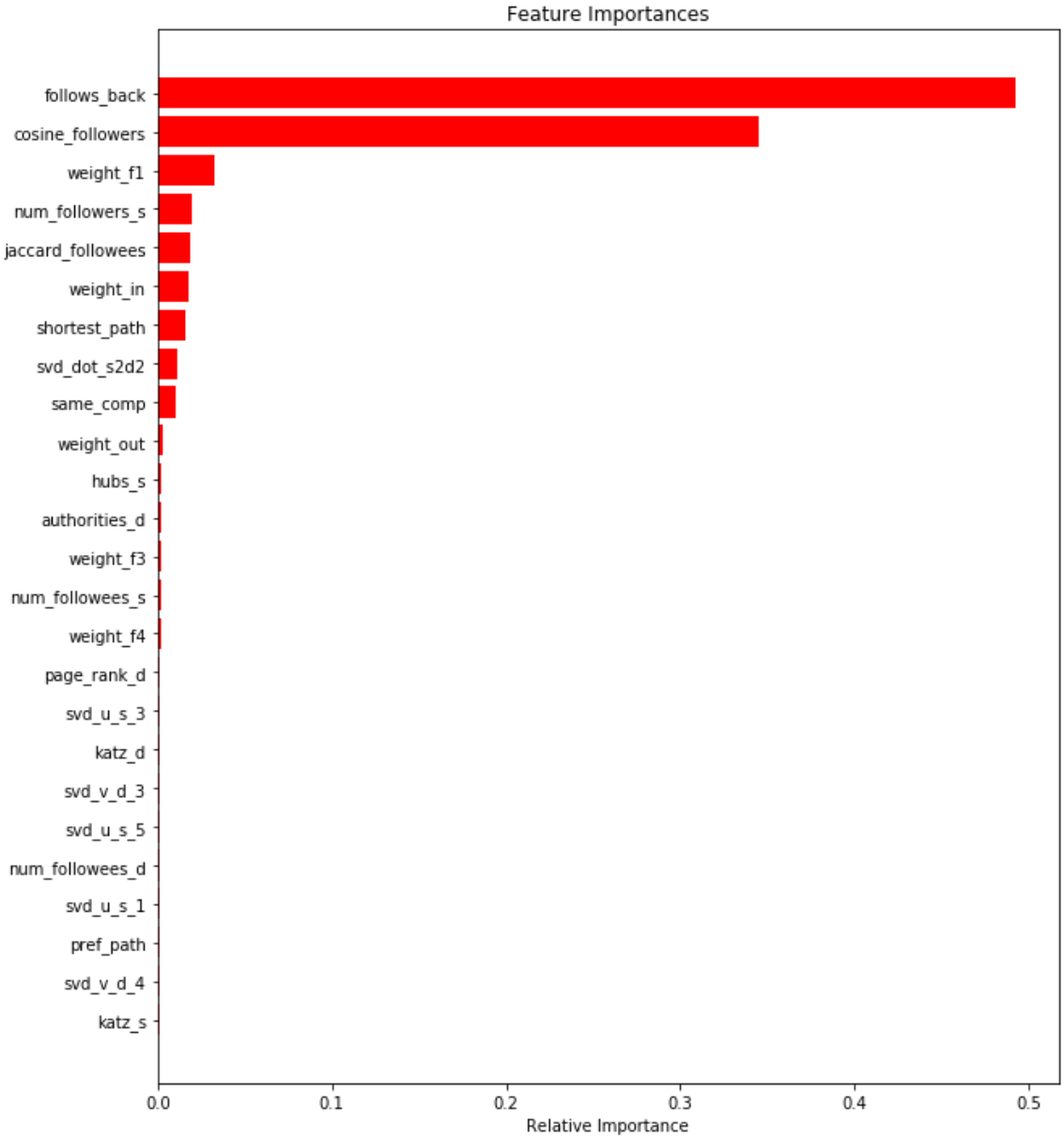
In [33]:

```
from sklearn.metrics import roc_curve, auc
fpr,tpr,ths = roc_curve(y_test,y_test_pred)
auc_sc = auc(fpr, tpr)
plt.plot(fpr, tpr, color='navy',label='ROC curve (area = %0.2f)' % auc_sc)
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('Receiver operating characteristic with test data')
plt.legend()
plt.show()
```



In [34]:

```
features = df_final_train.columns
importances = clf.feature_importances_
indices = (np.argsort(importances))[-25:]
plt.figure(figsize=(10,12))
plt.title('Feature Importances')
plt.barh(range(len(indices)), importances[indices], color='r', align='center')
plt.yticks(range(len(indices)), [features[i] for i in indices])
plt.xlabel('Relative Importance')
plt.show()
```



CONCLUSION AND STEPS FOLLOWED:

A. EDA:

1. Initially we removed the duplicate ponits.
2. We used networkx library to observe all the points and their properties.
3. We obderved that average indegree score is 0.75 and average outdegree score is 0.75.
4. Then we tried to get the number of followers for each person by plotting graphs.
5. We observed that 99% percentile of people having only 40 followers.

B. Featurization:

1. We tried to featurize the data points using various graph algorithms like Jaccard distance for followers and followees, also cosine distance which are explained briefly above.
2. We had utilized ranking features like page ranking.
3. Graph features :- shortest path, checking for same community, Adamic/Adar Index, preferrential attachment, is person following back, kartz certrality, Hits score.
4. Finally we tried out svd features like svd for followers and followees. We also tried to multiply the 6 features for source and destination.

C. Model:

1. We tried to build our model using Random Forest because there was no contraint for latency.
2. We know random forest has perdicts us with higher accuracy level, so it was the best choice.
3. We tried to build model with sklearn library's RandomForestClassifier and XGBOOST.
4. Train and test f1-score for RandomForestClassifier are 0.962 and 0.922 respectively
5. Train and test f1-score for xgboostClassifier are 0.99 and 0.926 respectively
6. Top 5 features for Random Forest classifier model were follow back, weight_f2, shortest path, weght_f1, inter_followers.
7. Top 5 features for XGBOOST classifier model were cosine_followers, weight_f1, num_followees_s, jaccardfolloers, weight_in.
8. Overall our model performed very well with a good f1-score.