OBJECTIVE

1. **APPLYING RANDOM FOREST WITH AVG WORD2VEC VECTORIZATION**
   - **FINDING THE BEST HYPERPARAMETER USING GRIDSEARCHCV WITH TRAIN DATA AND CROSS-VALIDATION DATA BY PLOTTING THE RESLUTS OF VAROIUS TRAIN DATA AND CROSS VALIDATION DATA**
   - **USING THE APROPRIATE VALUE OF HYPERPARAMETER ,TESTING ACCURACY ON TEST DATA USING F1-SCORE**
   - **PLOTTING THE CONFUSION MATRIX TO GET THE PRECISOIN ,RECALL VALUE WITH HELP OF HEATMAP**
   - **PRINTING THE TOP 30 MOST IMPORTANT FEATURES**

In [0]:
```
from sklearn.model_selection import train_test_split          #importin
g the necessary libraries
from sklearn.model_selection import RandomizedSearchCV
from sklearn.datasets import *
from sklearn import naive_bayes
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
import numpy as np
import pandas as pd
from sklearn import *
import warnings
warnings.filterwarnings("ignore")
from sklearn.ensemble import RandomForestClassifier
from gensim.models import Word2Vec
from tqdm import tqdm
```

In [8]:
```
from google.colab import drive
drive.mount('/content/gdrive')#geeting the content from the google driv
e
```

```
Drive already mounted at /content/gdrive; to attempt to forcibly remoun
```

```
t, call drive.mount("/content/gdrive", force_remount=True).
```

In [0]:
```
final_processed_data=pd.read_csv("gdrive/My Drive/final_new_data.csv")#
loading the preprocessed data  with 100k points into dataframe
```

In [10]:
```
# getting the counts of 0 and 1 in "SCORE" column to know whether it is
 unbalanced data or not
count_of_1=0
count_of_0=0
for i in final_processed_data['Score']:
   if i==1:
    count_of_1+=1
   else:
    count_of_0+=1
print(count_of_1)
print(count_of_0)
#it is an imbalanced dataset
```

```
88521
11479
```

In [0]:
```
#spliiting the data into train and test data
x_train,x_test,y_train,y_test=model_selection.train_test_split(final_pr
ocessed_data['CleanedText'].values,final_processed_data['Score'].values
,test_size=0.3,shuffle=False)
```

In [15]:
```
list_of_sent=[]
for sent in x_train:
 list_of_sent.append(sent.split())#splitting of sentences into words AN
D appending them to list
print(x_train[0])
print("**********************************************************************
*")
print(list_of_sent[0])
word_to_vector=Word2Vec(list_of_sent,min_count=5,size=50,workers=2)#con
structing my our word to vector
w_t_c_words=list(word_to_vector.wv.vocab)
print("**********************************************************************
```

```
*******")
print("sample words ", w_t_c_words[0:50])
```

```
witti littl book make son laugh loud recit car drive along alway sing r
efrain hes learn whale india droop love new word book introduc silli cl
assic book will bet son still abl recit memori colleg
**************************************************************
['witti', 'littl', 'book', 'make', 'son', 'laugh', 'loud', 'recit', 'ca
r', 'drive', 'along', 'alway', 'sing', 'refrain', 'hes', 'learn', 'whal
e', 'india', 'droop', 'love', 'new', 'word', 'book', 'introduc', 'sill
i', 'classic', 'book', 'will', 'bet', 'son', 'still', 'abl', 'recit',
'memori', 'colleg']
**************************************************************************
sample words  ['witti', 'littl', 'book', 'make', 'son', 'laugh', 'lou
d', 'car', 'drive', 'along', 'alway', 'sing', 'hes', 'learn', 'india',
'droop', 'love', 'new', 'word', 'introduc', 'silli', 'classic', 'will',
'bet', 'still', 'abl', 'memori', 'colleg', 'rememb', 'see', 'show', 'ai
r', 'televis', 'year', 'ago', 'child', 'sister', 'later', 'bought', 'da
y', 'thirti', 'someth', 'use', 'seri', 'song', 'student', 'teach', 'pre
school', 'turn', 'whole']
```

In [18]:

```
###### NOW STARTING AVERAGE WORD TO VEC FOR TRAIN DATA#################
################################################
train_sent_vectors = []; # the avg-w2v for each sentence/review is stor
ed in this list
for sent in tqdm(list_of_sent): # for each review/sentence
 sent_vec = np.zeros(50) # as word vectors are of zero length
 cnt_words =0; # num of words with a valid vector in the sentence/revie
w
 for word in sent: # for each word in a review/sentence
   if word in w_t_c_words:
     vec = word_to_vector.wv[word]
     sent_vec += vec
     cnt_words += 1
 if cnt_words != 0:
  sent_vec /= cnt_words
 train_sent_vectors.append(sent_vec)
print(len(train_sent_vectors))
print(len(train_sent_vectors[0]))
```

```
100%|██████████| 70000/70000 [01:25<00:00, 814.41it/s]
```

```
70000
50
```

In [19]:
```
from sklearn.preprocessing import StandardScaler #standarizing the trai
ning  data
x_train_data=StandardScaler( with_mean=False).fit_transform(train_sent_
vectors)
print(x_train_data.shape)
```

```
(70000, 50)
```

In [20]:
```
list_of_sent=[]
for sent in x_test:
 list_of_sent.append(sent.split())#splitting of sentences into words AN
D appending them to list
print(x_test[0])
print("**********************************************************************
*")
print(list_of_sent[0])
print('**********************************************************************
***')
```

```
product carbon fruit juic high fructos corn syrup pack calori littl pro
duct prefer drink calori plain water tast wasnt pleas left unpleas afte
rtast also sweet drink made less thirst quencher
**********************************************************************
['product', 'carbon', 'fruit', 'juic', 'high', 'fructos', 'corn', 'syru
p', 'pack', 'calori', 'littl', 'product', 'prefer', 'drink', 'calori',
'plain', 'water', 'tast', 'wasnt', 'pleas', 'left', 'unpleas', 'afterta
st', 'also', 'sweet', 'drink', 'made', 'less', 'thirst', 'quencher']
**********************************************************************
```

In [21]:
```
###### NOW STARTING AVERAGE WORD TO VEC FOR TEST DATA##################
################################################
sent_vectors = []; # the avg-w2v for each sentence/review is stored in
 this list
```

```
for sent in tqdm(list_of_sent): # for each review/sentence
 sent_vec = np.zeros(50) # as word vectors are of zero length
 cnt_words =0; # num of words with a valid vector in the sentence/revie
w
 for word in sent: # for each word in a review/sentence
   if word in w_t_c_words:
     vec = word_to_vector.wv[word]
     sent_vec += vec
     cnt_words += 1
 if cnt_words != 0:
  sent_vec /= cnt_words
 sent_vectors.append(sent_vec)
print(len(sent_vectors))
print(len(sent_vectors[0]))
```

```
100%|██████████| 30000/30000 [00:38<00:00, 786.82it/s]
```

```
30000
50
```

In [41]:

```
from sklearn.preprocessing import StandardScaler #standarizing the trai
ning  data
x_test_data=StandardScaler( with_mean=False).fit_transform(sent_vectors
)
print(x_test_data.shape)
```

```
(30000, 50)
```

In [31]:

```
#biudling the model
#using time series split method for cross-validation score
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)
rf=RandomForestClassifier(criterion='gini',class_weight={1:.5,0:.5})
tuned_parameters=[{'max_depth':[20,30,40,50,60,80],'n_estimators':[21,3
0,40,50,70,100]}]
#applying the model of decision tree and using gridsearchcv to find the
 best hyper parameter
%time
from sklearn.model_selection import GridSearchCV
```

```
model = GridSearchCV(rf, tuned_parameters, scoring = 'f1', cv=tscv,n_jo
bs=-1)#building the gridsearchcv model
```

```
CPU times: user 3 µs, sys: 0 ns, total: 3 µs
Wall time: 6.2 µs
```

In [32]:
```
%%time
model.fit(x_train_data, y_train)#fiitting the training data
```

```
CPU times: user 48.4 s, sys: 276 ms, total: 48.7 s
Wall time: 34min 46s
```

Out[32]:
```
GridSearchCV(cv=TimeSeriesSplit(max_train_size=None, n_splits=5),
       error_score='raise-deprecating',
       estimator=RandomForestClassifier(bootstrap=True, class_weight=
{1: 0.5, 0: 0.5},
            criterion='gini', max_depth=None, max_features='auto',
            max_leaf_nodes=None, min_impurity_decrease=0.0,
            min_impurity_split=None, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators='warn', n_jobs=None, oob_score=False,
            random_state=None, verbose=0, warm_start=False),
       fit_params=None, iid='warn', n_jobs=-1,
       param_grid=[{'max_depth': [20, 30, 40, 50, 60, 80], 'n_estimator
s': [21, 30, 40, 50, 70, 100]}],
       pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
       scoring='f1', verbose=0)
```

In [33]:
```
print(model.best_estimator_)#printing the best_estimator
```

```
RandomForestClassifier(bootstrap=True, class_weight={1: 0.5, 0: 0.5},
            criterion='gini', max_depth=80, max_features='auto',
            max_leaf_nodes=None, min_impurity_decrease=0.0,
            min_impurity_split=None, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators=70, n_jobs=None, oob_score=False,
            random_state=None, verbose=0, warm_start=False)
```

In [34]:
```
results=pd.DataFrame(model.cv_results_)# getting varoius cv_scores and
```

```
 train_scores various values of hyperparameter given as parameter and s
toring it in a dataframe
results.head()#printing the dataframe
```

Out[34]:

	mean_fit_time	mean_score_time	mean_test_score	mean_train_score	param_max_de
0	8.740210	0.057351	0.944865	0.996863	20
1	12.501804	0.077723	0.946017	0.997540	20
2	16.637933	0.101920	0.945213	0.997816	20
3	20.628283	0.124750	0.946391	0.997981	20
4	28.996505	0.173270	0.946063	0.998126	20

5 rows × 22 columns

In [0]:
```
results['mean_test_score']=results['mean_test_score']*100
results=results.round(decimals=2)
results['cv_error_score']=100-results['mean_test_score']
```

PLOTTING THE HEATMAP WITH HYPERPARAMETERS FOR CV_ERROR SCORE

In [0]:
```
test_score_heatmap=results.pivot(       'param_max_depth'       ,'param
_n_estimators','cv_error_score' )
```

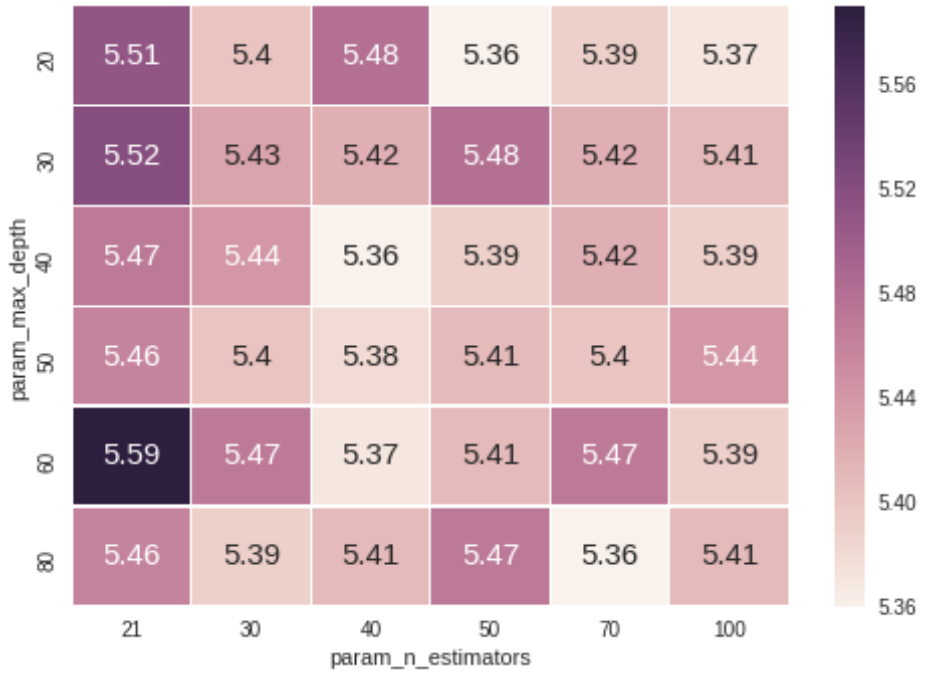
In [37]:
```
test_score_heatmap
```

Out[37]:

param_n_estimators	21	30	40	50	70	100
param_max_depth						
20	5.51	5.40	5.48	5.36	5.39	5.37
30	5.52	5.43	5.42	5.48	5.42	5.41
40	5.47	5.44	5.36	5.39	5.42	5.39
50	5.46	5.40	5.38	5.41	5.40	5.44
60	5.59	5.47	5.37	5.41	5.47	5.39
80	5.46	5.39	5.41	5.47	5.36	5.41

In [38]:
```
import seaborn as sns
sns.heatmap(test_score_heatmap,annot=True,annot_kws={"size": 15}, fmt=
'g',linewidths=.3)
```

Out[38]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5f4f2d8c88>
```



In [39]:
```
print(model.best_estimator_)#printing the best_estimator
```

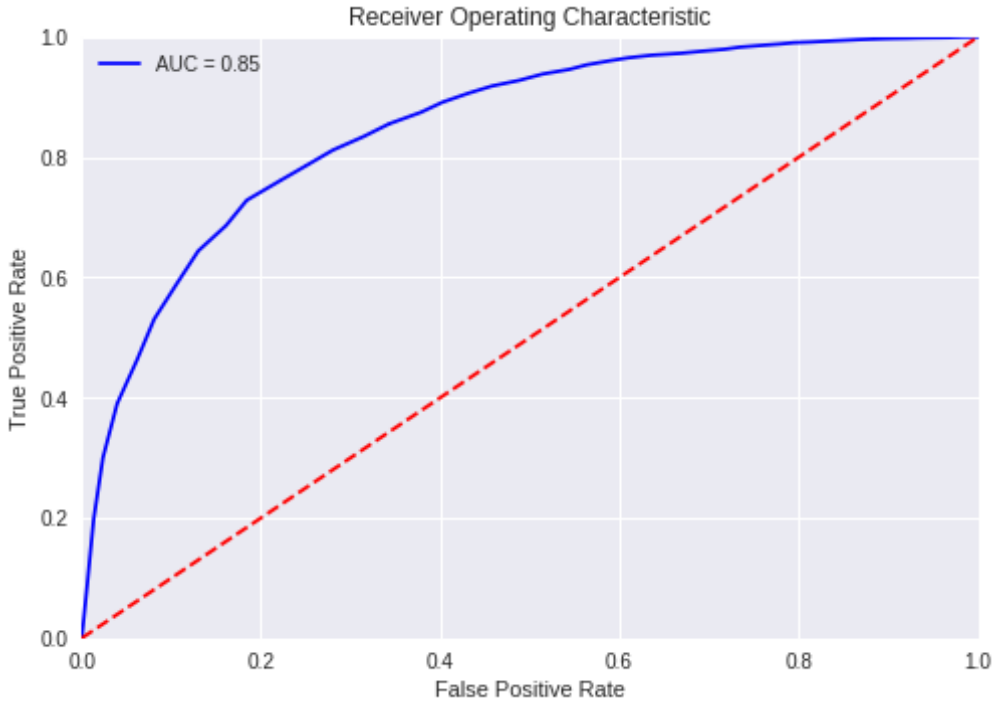
```
RandomForestClassifier(bootstrap=True, class_weight={1: 0.5, 0: 0.5},
            criterion='gini', max_depth=80, max_features='auto',
            max_leaf_nodes=None, min_impurity_decrease=0.0,
            min_impurity_split=None, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators=70, n_jobs=None, oob_score=False,
            random_state=None, verbose=0, warm_start=False)
```

FROM THE ABOVE HEATMAPS RESULTS FOR CV DATA,WE FOUND THAT BEST HYPERPARAMETERS AS MAX_DEPTH=80 AND N_ESTIMATORS=70

PLOTTING THE ROC CURVE FOR GETTING AUC SCORE

In [42]:
```
rf=RandomForestClassifier(criterion='gini',class_weight={1:.5,0:.5},max
_depth=80 ,n_estimators=70)
rf.fit(x_train_data,y_train)#fitting the model
probs = rf.predict_proba(x_test_data)
preds = probs[:,1]
fpr, tpr, threshold = metrics.roc_curve(y_test, preds)
roc_auc = metrics.auc(fpr, tpr)

#plotting the auc curve with best hyperparameters to get auc value
import matplotlib.pyplot as plt
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'best')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```



In [43]:
```
print('accuracy from the ROC curve is found as ',roc_auc*100)
```

```
accuracy from the ROC curve is found as  85.112476107286
```

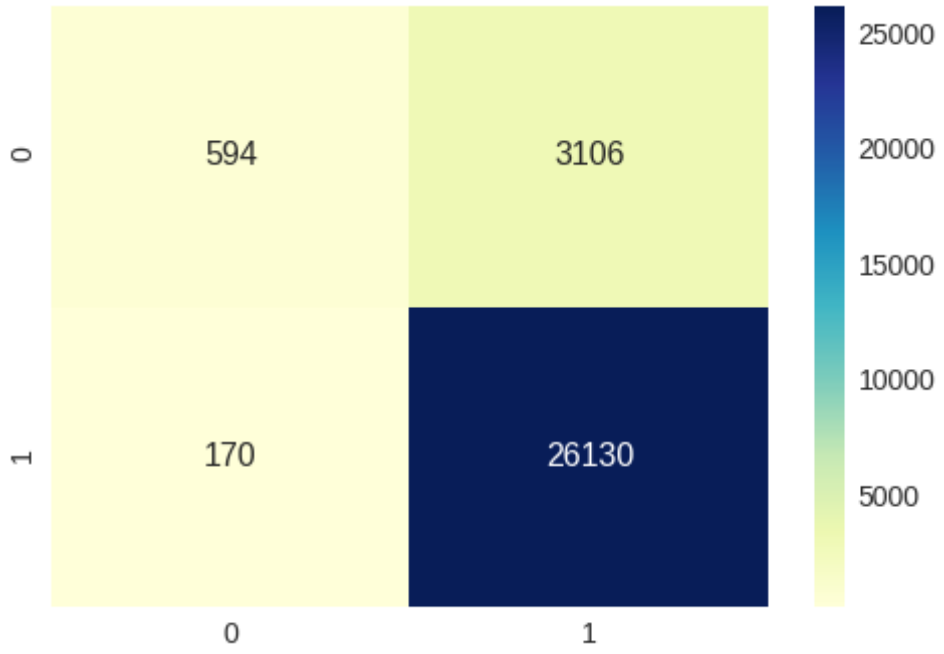
TESTING OUR MODEL ON TEST DATA AND CHECKING ITS PRECISION ,RECALL ,F1_FCORE

In [44]:
```
#Testing Accuracy on Test data
import seaborn as sns #importing seaborn as sns
from sklearn.metrics import *#importing varoius metrics from sklearn
#building the model
y_pred = rf.predict(x_test_data)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred)*1
```

```
00))#printing accuracy
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred)))
#printing precision score
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred))) #prin
ting recall
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred)))
print("Confusion Matrix of test set:\n [ [TN  FP]\n [FN TP] ]\n")
df_cm = pd.DataFrame(confusion_matrix(y_test, y_pred), range(2),range(2
)) #generating the heatmap for confusion matrix
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g',cmap="YlG
nBu")
```

```
Accuracy on test set: 89.080%
Precision on test set: 0.894
Recall on test set: 0.994
F1-Score on test set: 0.941
Confusion Matrix of test set:
 [ [TN  FP]
 [FN TP] ]
```

Out[44]: <matplotlib.axes._subplots.AxesSubplot at 0x7f5f4ea1ea90>



AVG WORD2VEC VECTORIZATION FOR RANDOM FOREST IS COMPLETED

OBJECTIVE

1. **APPLYING GBDT WITH AVG WORD2VEC VECTORIZATION**
   - **FINDING THE BEST HYPERPARAMETER USING GRIDSEARCHCV WITH TRAIN DATA AND CROSS-VALIDATION DATA BY PLOTTING THE RESLUTS OF VAROIUS TRAIN DATA AND CROSS VALIDATION DATA**
   - **USING THE APROPRIATE VALUE OF HYPERPARAMETER ,TESTING ACCURACY ON TEST DATA USING F1-SCORE**
   - **PLOTTING THE CONFUSION MATRIX TO GET THE PRECISOIN ,RECALL VALUE WITH HELP OF HEATMAP**

- **PRINTING THE TOP 30 MOST IMPORTANT FEATURES**

In [45]:
```
from xgboost import XGBClassifier
#biudling the model
#using time series split method for cross-validation score
from sklearn.model_selection import TimeSeriesSplit
tscv = TimeSeriesSplit(n_splits=5)
xg=XGBClassifier(n_jobs=-1)
tuned_parameters=[{'max_depth':[20,30,40,50,60,80],'n_estimators':[21,3
0,40,50,70,100]}]
#applying the model of decision tree and using gridsearchcv to find the
 best hyper parameter
%time
from sklearn.model_selection import GridSearchCV
model = GridSearchCV(xg, tuned_parameters, scoring = 'f1', cv=tscv,n_jo
bs=-1)#building the gridsearchcv model
```

```
CPU times: user 3 µs, sys: 0 ns, total: 3 µs
Wall time: 6.2 µs
```

In [46]:
```
%%time
model.fit(x_train_data, y_train)#fiitting the training data
```

```
CPU times: user 2min 8s, sys: 386 ms, total: 2min 9s
Wall time: 1h 17min 46s
```

Out[46]:
```
GridSearchCV(cv=TimeSeriesSplit(max_train_size=None, n_splits=5),
       error_score='raise-deprecating',
       estimator=XGBClassifier(base_score=0.5, booster='gbtree', colsam
ple_bylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=
0,
       max_depth=3, min_child_weight=1, missing=None, n_estimators=100,
       n_jobs=-1, nthread=None, objective='binary:logistic',
       random_state=0, reg_alpha=0, reg_lambda=1, scale_pos_weight=1,
       seed=None, silent=True, subsample=1),
       fit_params=None, iid='warn', n_jobs=-1,
       param_grid=[{'max_depth': [20, 30, 40, 50, 60, 80], 'n_estimator
s': [21, 30, 40, 50, 70, 100]}],
```

```
        pre_dispatch='2*n_jobs', refit=True, return_train_score='warn',
        scoring='f1', verbose=0)
```

In [47]:
```
print(model.best_estimator_)#printing the 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=40, min_child_weight=1, missing=None, n_estimators=10
0,
       n_jobs=-1, nthread=None, objective='binary:logistic',
       random_state=0, reg_alpha=0, reg_lambda=1, scale_pos_weight=1,
       seed=None, silent=True, subsample=1)
```

In [48]:
```
results=pd.DataFrame(model.cv_results_)# getting varoius cv_scores and
 train_scores various values of hyperparameter given as parameter and s
toring it in a dataframe
results.head()#printing the dataframe
```

Out[48]:

	mean_fit_time	mean_score_time	mean_test_score	mean_train_score	param_max_de
0	21.150612	0.071006	0.944721	0.996258	20
1	29.628869	0.097126	0.946084	0.998488	20
2	38.470601	0.124978	0.946626	0.999468	20

	mean_fit_time	mean_score_time	mean_test_score	mean_train_score	param_max_de
3	46.729607	0.147422	0.947057	0.999787	20
4	62.315705	0.208297	0.947818	0.999981	20

5 rows × 22 columns

In [0]:
```
results['mean_test_score']=results['mean_test_score']*100

results=results.round(decimals=2)

results['cv_error_score']=100-results['mean_test_score']
```

PLOTTING THE HEATMAP WITH HYPERPARAMETERS FOR CV_ERROR SCORE

In [50]:
```
test_score_heatmap=results.pivot( 'param_max_depth' ,'param_n_estimators','cv_error_score'  )

test_score_heatmap
```

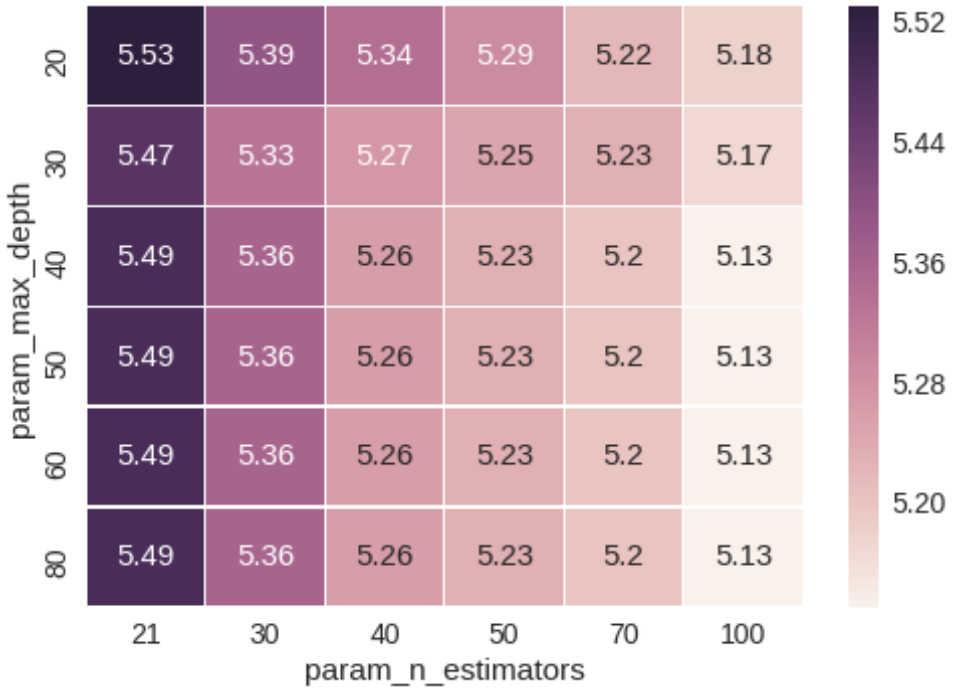
Out[50]:

param_n_estimators	21	30	40	50	70	100
param_max_depth						

param_n_estimators	21	30	40	50	70	100
param_max_depth						
20	5.53	5.39	5.34	5.29	5.22	5.18
30	5.47	5.33	5.27	5.25	5.23	5.17
40	5.49	5.36	5.26	5.23	5.20	5.13
50	5.49	5.36	5.26	5.23	5.20	5.13
60	5.49	5.36	5.26	5.23	5.20	5.13
80	5.49	5.36	5.26	5.23	5.20	5.13

In [51]:
```
import seaborn as sns
sns.heatmap(test_score_heatmap,annot=True,annot_kws={"size": 15}, fmt=
'g',linewidths=.3)
```

Out[51]:
```
<matplotlib.axes._subplots.AxesSubplot at 0x7f5f4e8ee400>
```



In [52]:
```
print(model.best_estimator_)#printing the 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=40, min_child_weight=1, missing=None, n_estimators=10
0,
       n_jobs=-1, nthread=None, objective='binary:logistic',
       random_state=0, reg_alpha=0, reg_lambda=1, scale_pos_weight=1,
       seed=None, silent=True, subsample=1)
```

FROM THE ABOVE HEATMAPS RESULTS FOR CV DATA,WE FOUND THAT BEST

HYPERPARAMETERS AS MAX_DEPTH=40 AND N_ESTIMATORS=100

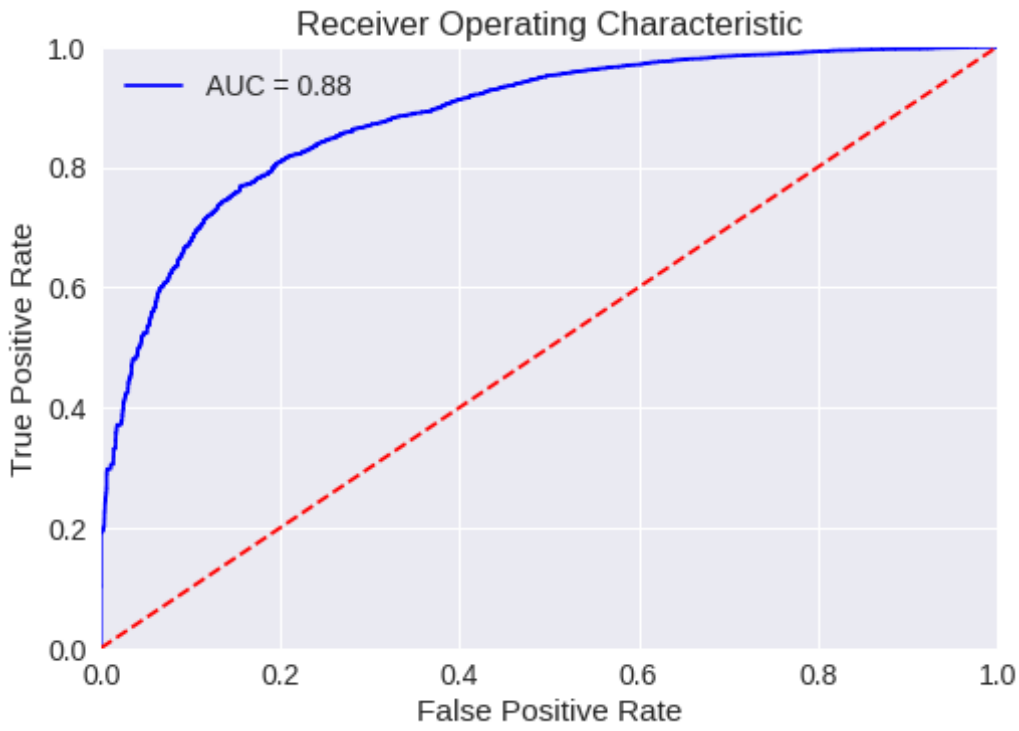
PLOTTING THE ROC CURVE FOR GETTING AUC SCORE

In [54]:
```
xg=XGBClassifier(n_jobs=-1,max_depth=40 ,n_estimators=100)
xg.fit(x_train_data,y_train)#fitting the model
```

Out[54]:
```
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=40, min_child_weight=1, missing=None, n_estimators=10
0,
       n_jobs=-1, nthread=None, objective='binary:logistic',
       random_state=0, reg_alpha=0, reg_lambda=1, scale_pos_weight=1,
       seed=None, silent=True, subsample=1)
```

In [55]:
```
probs = xg.predict_proba(x_test_data)
preds = probs[:,1]
fpr, tpr, threshold = metrics.roc_curve(y_test, preds)
roc_auc = metrics.auc(fpr, tpr)

import matplotlib.pyplot as plt
plt.title('Receiver Operating Characteristic')
plt.plot(fpr, tpr, 'b', label = 'AUC = %0.2f' % roc_auc)
plt.legend(loc = 'best')
plt.plot([0, 1], [0, 1],'r--')
plt.xlim([0, 1])
plt.ylim([0, 1])
plt.ylabel('True Positive Rate')
plt.xlabel('False Positive Rate')
plt.show()
```



In [57]:
```
print('accuracy from the ROC curve is found as ',roc_auc*100)
```

```
accuracy from the ROC curve is found as  88.3943536121673
```

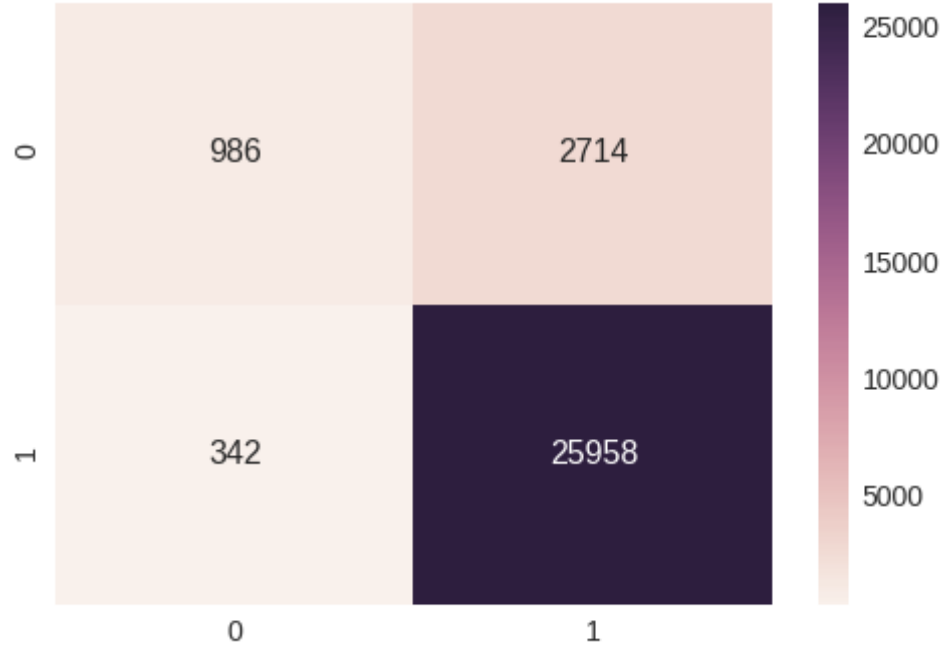
TESTING OUR MODEL ON TEST DATA AND CHECKING ITS PRECISION ,RECALL ,F1_FCORE

In [56]:
```
y_pred = xg.predict(x_test_data)
print("Accuracy on test set: %0.3f%%"%(accuracy_score(y_test, y_pred)*100))#printing accuracy
print("Precision on test set: %0.3f"%(precision_score(y_test, y_pred)))
#printing precision score
```

```
print("Recall on test set: %0.3f"%(recall_score(y_test, y_pred))) #prin
ting recall
print("F1-Score on test set: %0.3f"%(f1_score(y_test, y_pred)))
print("Confusion Matrix of test set:\n [ [TN  FP]\n [FN TP] ]\n")
df_cm = pd.DataFrame(confusion_matrix(y_test, y_pred), range(2),range(2
)) #generating the heatmap for confusion matrix
sns.set(font_scale=1.4)#for label size
sns.heatmap(df_cm, annot=True,annot_kws={"size": 16}, fmt='g')
```

```
Accuracy on test set: 89.813%
Precision on test set: 0.905
Recall on test set: 0.987
F1-Score on test set: 0.944
Confusion Matrix of test set:
 [ [TN  FP]
 [FN TP] ]
```

Out[56]: <matplotlib.axes._subplots.AxesSubplot at 0x7f5f4e9297b8>



avg word2vec for random forest and gbdt is completed