[1] Amazon Fine Food Reviews Analysis

Data Source: https://www.kaggle.com/snap/amazon-fine-food-reviews (https://www.kaggle.com/snap/amazon-fine-food-reviews)

The Amazon Fine Food Reviews dataset consists of reviews of fine foods from Amazon.

Number of reviews: 568,454
Number of users: 256,059
Number of products: 74,258
Timespan: Oct 1999 - Oct 2012
Number of Attributes/Columns in data: 10

Attribute Information:

1. Id
2. ProductId - unique identifier for the product
3. UserId - unqiue identifier for the user
4. ProfileName
5. HelpfulnessNumerator - number of users who found the review helpful
6. HelpfulnessDenominator - number of users who indicated whether they found the review helpful or not
7. Score - rating between 1 and 5
8. Time - timestamp for the review
9. Summary - brief summary of the review
10. Text - text of the review

Objective:

Given a review, determine whether the review is positive (Rating of 4 or 5) or negative (rating of 1 or 2).

[Q] How to determine if a review is positive or negative?

[Ans] We could use the Score/Rating. A rating of 4 or 5 could be cosnidered a positive review. A review of 1 or 2 could be considered negative. A review of 3 is nuetral and ignored. This is an approximate and proxy way of determining the polarity (positivity/negativity) of a review.

[7.1] Loading the data

The dataset is available in two forms

1. .csv file
2. SQLite Database

In order to load the data, We have used the SQLITE dataset as it easier to query the data and visualise the data efficiently.

Here as we only want to get the global sentiment of the recommendations (positive or negative), we will purposefully ignore all Scores equal to 3. If the score id above 3, then the recommendation wil be set to "positive". Otherwise, it will be set to "negative".

In [1]:

```
import warnings
from sklearn.exceptions import DataConversionWarning
warnings.filterwarnings(action='ignore', category=DataConversionWarning)
warnings.filterwarnings(action='ignore', category=UserWarning)
warnings.filterwarnings(action='ignore', category=FutureWarning)

import math
import random
import traceback
import sqlite3
import itertools
import datetime as dt
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sn
from tqdm import tqdm
from sklearn import preprocessing
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.model_selection import train_test_split
from prettytable import PrettyTable
from sklearn.metrics import accuracy_score,precision_score,recall_score,confusion_matrix,cl
from sklearn.metrics import make_scorer
from scipy.stats import uniform
from scipy.sparse import find
from sklearn.externals import joblib
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import RandomizedSearchCV
from sklearn.model_selection import TimeSeriesSplit
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
from gensim.models import word2vec
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\externals\joblib\__init_
_.py:15: DeprecationWarning: sklearn.externals.joblib is deprecated in 0.21
and will be removed in 0.23. Please import this functionality directly from
joblib, which can be installed with: pip install joblib. If this warning is
raised when loading pickled models, you may need to re-serialize those model
s with scikit-learn 0.21+.
  warnings.warn(msg, category=DeprecationWarning)
```

Exploratory Data Analysis

[7.1.2] Data Cleaning: Deduplication

It is observed (as shown in the table below) that the reviews data had many duplicate entries. Hence it was necessary to remove duplicates in order to get unbiased results for the analysis of the data. Following is an example:

In [2]:

```
#Using sqlite3 to retrieve data from sqlite file

con = sqlite3.connect("final.sqlite")#Loading Cleaned/ Preprocesed text that we did in Text

#Using pandas functions to query from sql table
final = pd.read_sql_query("""
SELECT * FROM Reviews order by Time
""",con)

#Reviews is the name of the table given
#Taking only the data where score != 3 as score 3 will be neutral and it won't help us much
final.head()
```

Out[2]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpfu
0	138706	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0	
1	138683	150501	0006641040	AJ46FKXOVC7NR	Nicholas A Mesiano	2	
2	417839	451856	B00004CXX9	AIUWLEQ1ADEG5	Elizabeth Medina	0	
3	346055	374359	B00004CI84	A344SMIA5JECGM	Vincent P. Ross	1	
4	417838	451855	B00004CXX9	AJH6LUC1UT1ON	The Phantom of the Opera	0	

In [3]:

```
#Sorting data according to ProductId in ascending order
sorted_data=final.sort_values('ProductId', axis=0, ascending=True, inplace=False, kind='qui

#Deduplication of entries
final=sorted_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='firs
```

In [4]:

```
final = final[final.HelpfulnessNumerator <= final.HelpfulnessDenominator]
```

Text Preprocessing: Stemming, stop-word removal and Lemmatization

In [5]:

```
import nltk
#set of stopwords in English
from nltk.corpus import stopwords
stop = set(stopwords.words('english'))
words_to_keep = set(('not'))
stop -= words_to_keep
#initialising the snowball stemmer
sno = nltk.stem.SnowballStemmer('english')

 #function to clean the word of any html-tags
def cleanhtml(sentence):
    cleanr = re.compile('<.*?>')
    cleantext = re.sub(cleanr, ' ', sentence)
    return cleantext

#function to clean the word of any punctuation or special characters
def cleanpunc(sentence):
    cleaned = re.sub(r'[?|!|\'|"|#]',r'',sentence)
    cleaned = re.sub(r'[.|,|)|(|\|/]',r' ',cleaned)
    return  cleaned
```

In [6]:

```
import re
#Code for removing HTML tags , punctuations . Code for removing stopwords . Code for checki
# also greater than 2 . Code for stemmimg and also to convert them to lowercase letters
i=0
str1=' '
final_string=[]
all_positive_words=[] # store words from +ve reviews here
all_negative_words=[] # store words from -ve reviews here.
s=''
for sent in final['Text'].values:
    filtered_sentence=[]
    #print(sent);
    sent=cleanhtml(sent) # remove HTML tags
    for w in sent.split():
        for cleaned_words in cleanpunc(w).split():
            if((cleaned_words.isalpha()) & (len(cleaned_words)>2)):
                if(cleaned_words.lower() not in stop):
                    s=(sno.stem(cleaned_words.lower())).encode('utf8')
                    filtered_sentence.append(s)
                    if (final['Score'].values)[i] == 'positive':
                        all_positive_words.append(s) #list of all words used to describe po
                    if(final['Score'].values)[i] == 'negative':
                        all_negative_words.append(s) #list of all words used to describe ne
                else:
                    continue
            else:
                continue

    str1 = b" ".join(filtered_sentence) #final string of cleaned words


    final_string.append(str1)
    i+=1
```

In [7]:

```
final['CleanedText']=final_string
final['CleanedText']=final['CleanedText'].str.decode("utf-8")
#below the processed review can be seen in the CleanedText Column
final.head()
```

Out[7]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator
288755	7137	7802	B00474H936	A2JT9TJ74UYK30	Laura	2
20630	479208	518195	B001E5E3LW	A156JLBSURBJE3	R. Corcoran "barryvillage2"	4
190985	210138	227746	B0033HPPIO	A3FLZCOLQMZ6J1	MrsKaraT	0
125128	140196	152146	B0002EOW4E	A1NE4STC8I0T6D	Jana Dengler	0
142392	9789	10707	B00389Q4XW	A23CDAI9ZJWVKO	Elaine	0

In [8]:

```
n_samples = 25000
final = final.sample(n_samples)

###Sorting as we want according to time series
final.sort_values('Time',inplace=True)
final.head(10)
```

Out[8]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDe
0	138706	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0	
9	346094	374400	B00004CI84	A2DEE7F9XKP3ZR	jerome	0	
21	138018	149790	B00004S1C6	A1IU7S4HCK1XK0	Joanna Daneman	25	
34	346113	374419	B00004CI84	ADIDORLLB4KBO	"paradise found"	2	

In [9]:

```
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=labels
    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=labels
    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=labels
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Recall matrix")

    plt.show()
```

Bag of Words (BoW)

In [10]:

```
x = final['CleanedText'].values
y = final['Score']

# split the data set into train and test
X_train, X_test, Y_train, Y_test = train_test_split(x, y, test_size=0.3, random_state=0)
```

In [11]:

```
count_vect = CountVectorizer(min_df = 10)
X_train_vec = count_vect.fit_transform(X_train)
X_test_vec = count_vect.transform(X_test)
print("the type of count vectorizer :",type(X_train_vec))
print("the shape of out text BOW vectorizer : ",X_train_vec.get_shape())
print("the number of unique words :", X_train_vec.get_shape()[1])
```

```
the type of count vectorizer : <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text BOW vectorizer :  (17500, 3790)
the number of unique words : 3790
```

Random Forest(RF) with GridSearchCV

In [12]:

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import accuracy_score,confusion_matrix,f1_score,precision_score,recall

base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]

depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]
param_grid = {'n_estimators': base_learners,'max_depth': depth}
RFC = RandomForestClassifier(max_features='sqrt')
model = GridSearchCV(RFC, param_grid, scoring = 'f1_weighted', cv=3 , n_jobs = -1,pre_dispa
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))
# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

optimal_depth=model.best_estimator_.max_depth
print("The optimal number of depth is : ",optimal_depth)
```

```
Model with best parameters :
 RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=120, max_features='sqrt', 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=10, n_jobs=None,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
Accuracy of the model :  0.854847789068937
The optimal number of base learners is :  10
The optimal number of depth is :  120
```

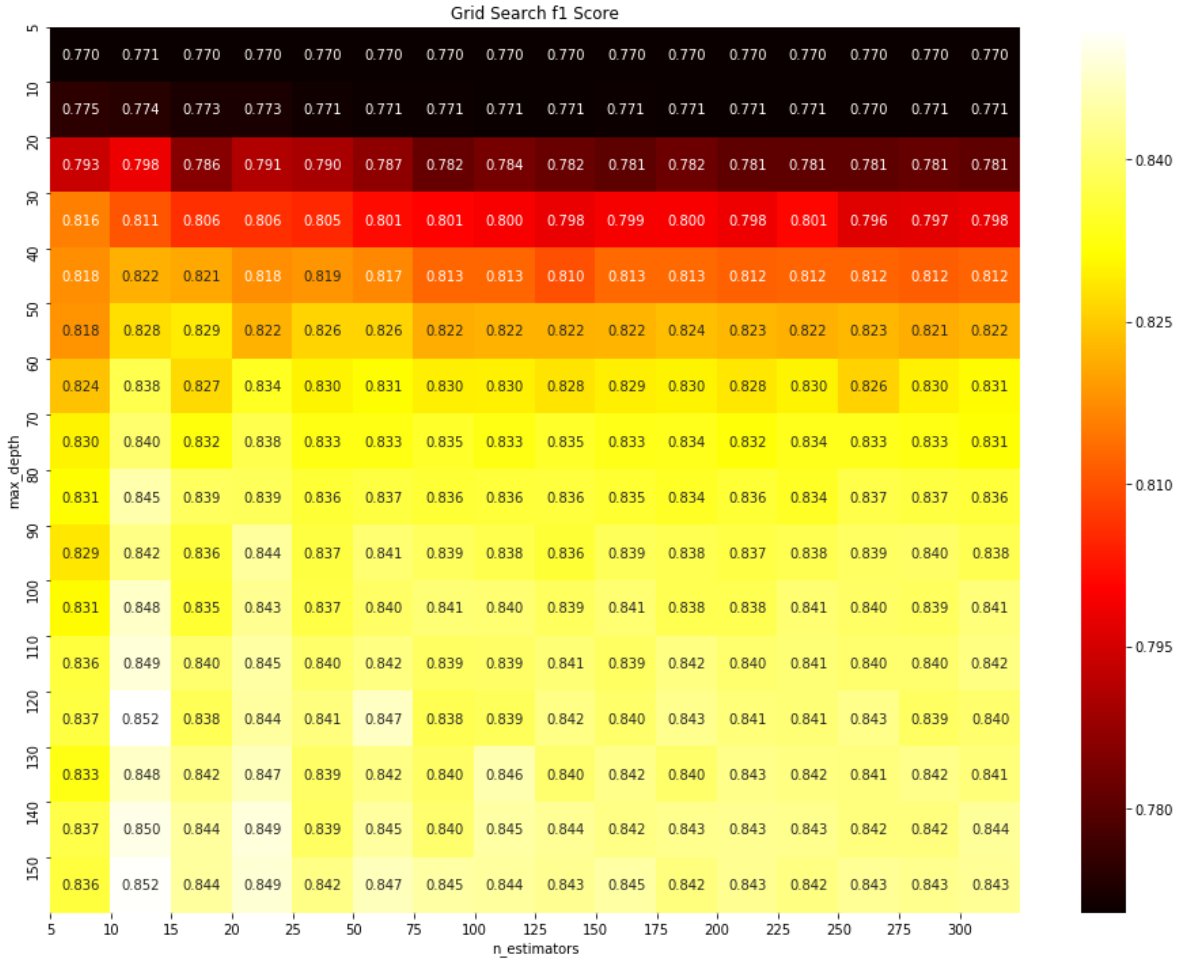
In [13]:

```
import seaborn as sns
```

In [14]:

```
print("Best HyperParameter: ",model.best_params_)
print(model.best_score_)
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```

```
Best HyperParameter:  {'max_depth': 120, 'n_estimators': 10}
0.8522059515926641
```



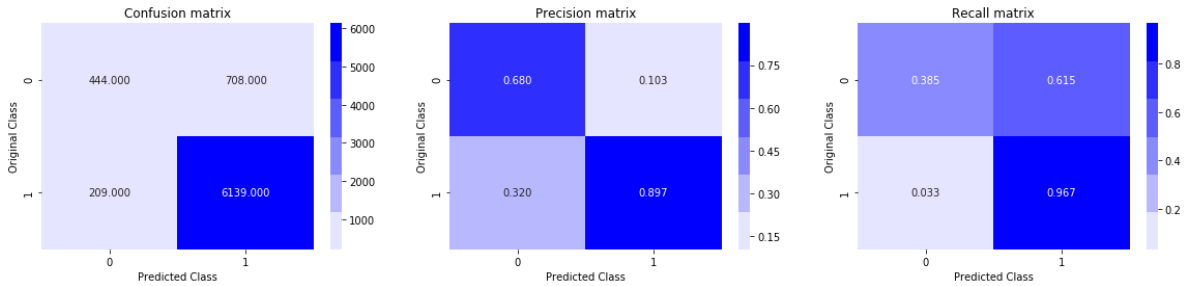
In [15]:

```
import seaborn as sns
```

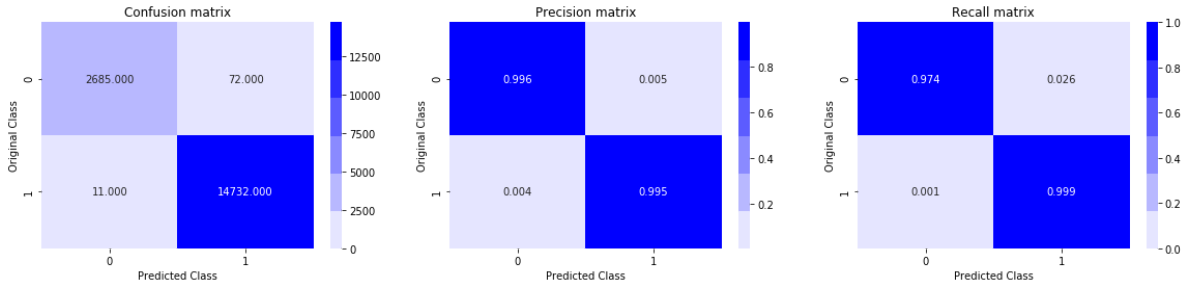
In [16]:

```
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
rf = RandomForestClassifier(n_estimators=optimal_learners, max_features='sqrt', n_jobs=-1)
rf.fit(X_train_vec,Y_train)
Y_pred = rf.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = rf.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
f1score= f1_score(Y_train, y_train_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter depth = 10 is:  87.773333%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8631446618220829
precision score  for   the model is: 0.8965970498028334
```




```
Accuracy of the model at optimal hyperparameter depth = 10 is:  99.525714%
f1 score value for   the model is: 0.9952355106965103
precision score  for   the model is: 0.995136449608214
```

Gradient Boosting Decision Tree(GBDT) with GridSearchCV

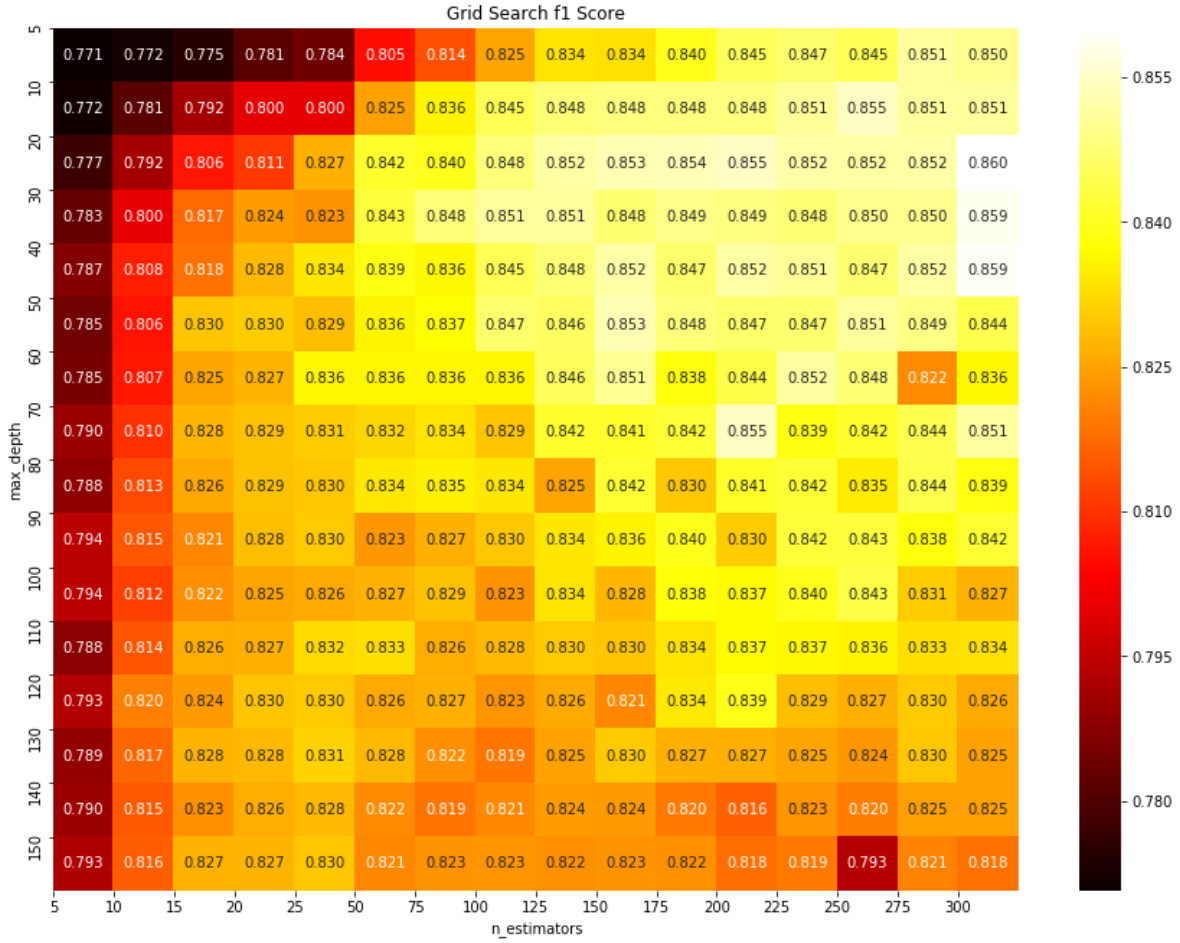
In [17]:

```
# Importing library
from sklearn.ensemble import GradientBoostingClassifier

base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]
depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]

param_grid = {'n_estimators': base_learners,  'max_depth': depth}
GBC = GradientBoostingClassifier(max_features='sqrt',subsample=0.1)
model = GridSearchCV(GBC, param_grid, scoring = 'f1_weighted', cv=3, n_jobs = -1,pre_dispat
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

# Optimal value of learning rate
optimal_depth = model.best_estimator_.max_depth
print("\nThe optimal value of max depth is : ",optimal_depth)
```

```
Model with best parameters :
 GradientBoostingClassifier(criterion='friedman_mse', init=None,
              learning_rate=0.1, loss='deviance', max_depth=20,
              max_features='sqrt', 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=300,
              n_iter_no_change=None, presort='auto', random_state=None,
              subsample=0.1, tol=0.0001, validation_fraction=0.1,
              verbose=0, warm_start=False)
Accuracy of the model :  0.8733301309514601
The optimal number of base learners is :  300

The optimal value of max depth is :  20
```

In [18]:

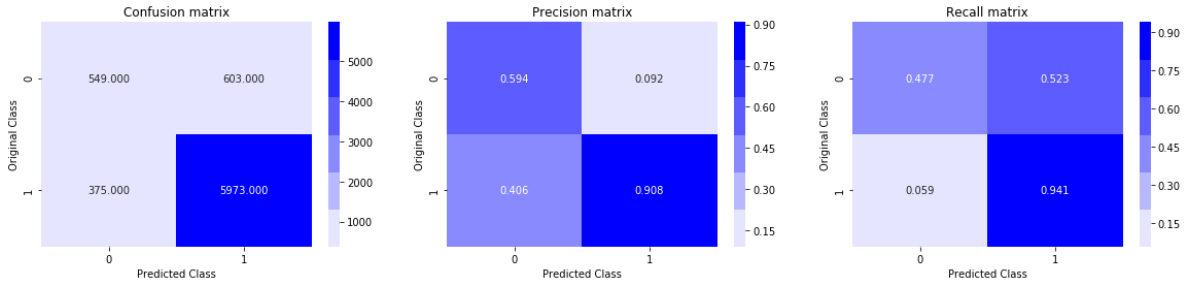
```
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(15, 11))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```



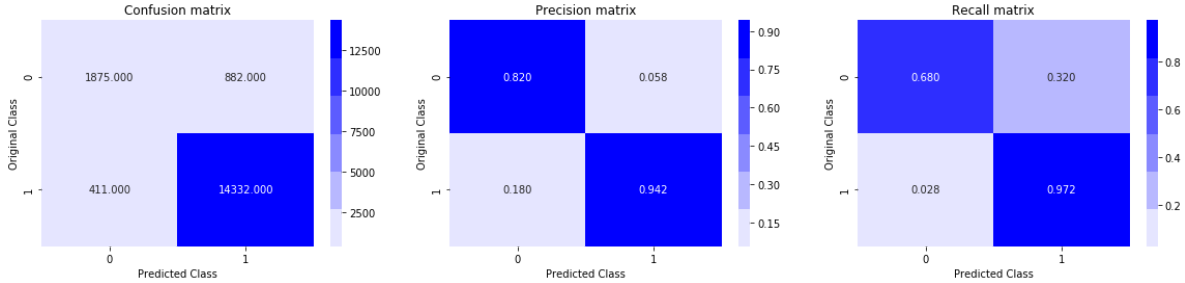
In [19]:

```
import seaborn as sns
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
gb = GradientBoostingClassifier(n_estimators=optimal_learners, max_depth=optimal_depth, max
gb.fit(X_train_vec,Y_train)
Y_pred = gb.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = gb.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
f1score= f1_score(Y_train, y_train_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter estimator = 300 is:  86.9600
00%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8635895384846582
precision score  for   the model is: 0.9083029197080292
```




```
Accuracy of the model at optimal hyperparameter estimator = 300 is:  92.6114
29%
f1 score value for   the model is: 0.9232447769192669
precision score  for   the model is: 0.9420270803207572
```

Term Frequency - Inverse Document Frequency (TF-IDF)

In [20]:

```
tf_idf_vect = TfidfVectorizer(min_df=10)
X_train_vec = tf_idf_vect.fit_transform(X_train)
X_test_vec = tf_idf_vect.transform(X_test)
print("the type of count vectorizer :",type(X_train_vec))
print("the shape of out text TFIDF vectorizer : ",X_train_vec.get_shape())
print("the number of unique words :", X_train_vec.get_shape()[1])
```

```
the type of count vectorizer : <class 'scipy.sparse.csr.csr_matrix'>
the shape of out text TFIDF vectorizer :  (17500, 3790)
the number of unique words : 3790
```

Random Forest(RF) with GridSearchCV

In [21]:

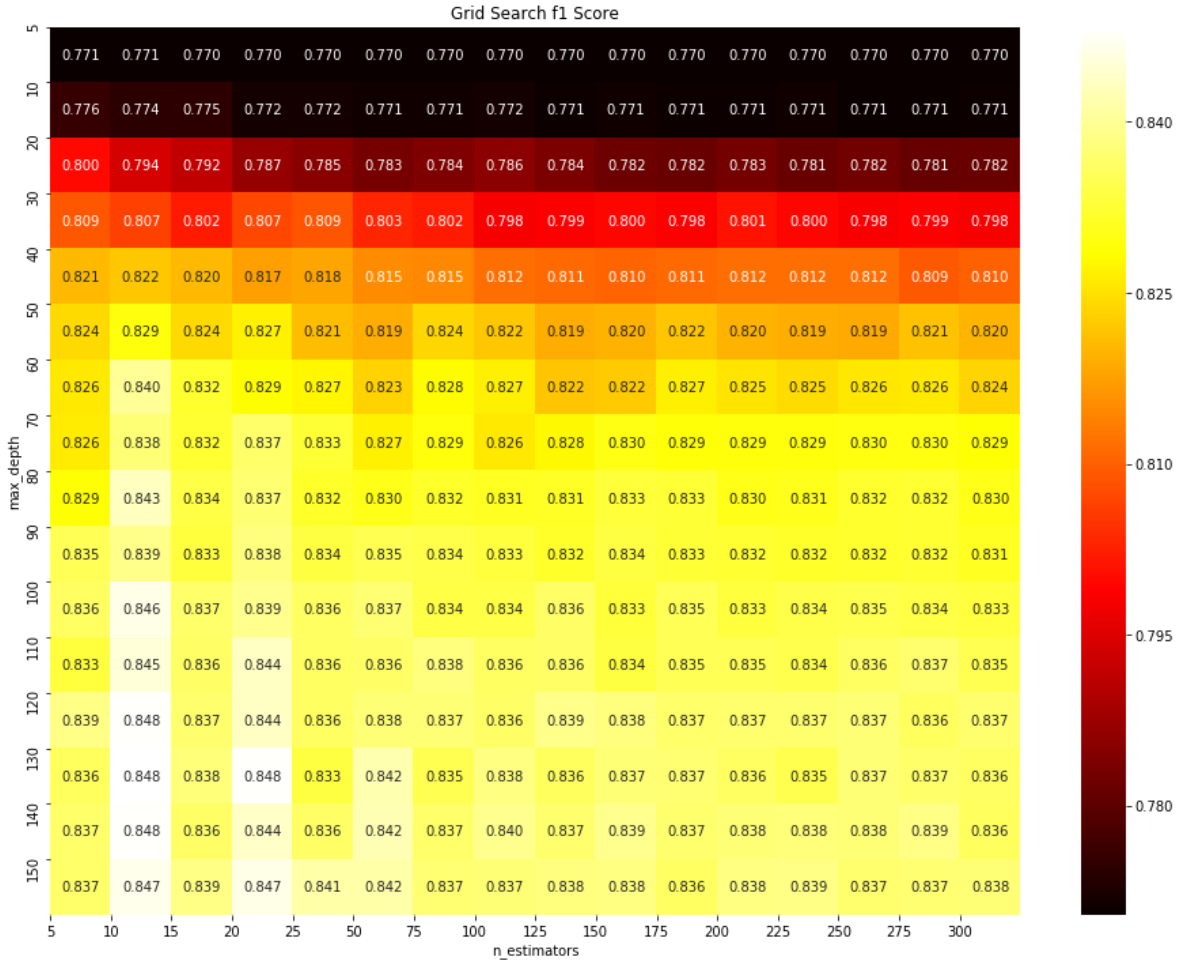
```


base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]

depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]
param_grid = {'n_estimators': base_learners,'max_depth': depth}
RFC = RandomForestClassifier(max_features='sqrt')
model = GridSearchCV(RFC, param_grid, scoring = 'f1_weighted', cv=3 , n_jobs = -1,pre_dispa
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

optimal_depth=model.best_estimator_.max_depth
print("The optimal number of depth is : ",optimal_depth)
```

```
Model with best parameters :
 RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=130, max_features='sqrt', 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=10, n_jobs=None,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
Accuracy of the model :  0.8614202901162389
The optimal number of base learners is :  10
The optimal number of depth is :  130
```

In [22]:

```
print("Best HyperParameter: ",model.best_params_)
print(model.best_score_)
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```

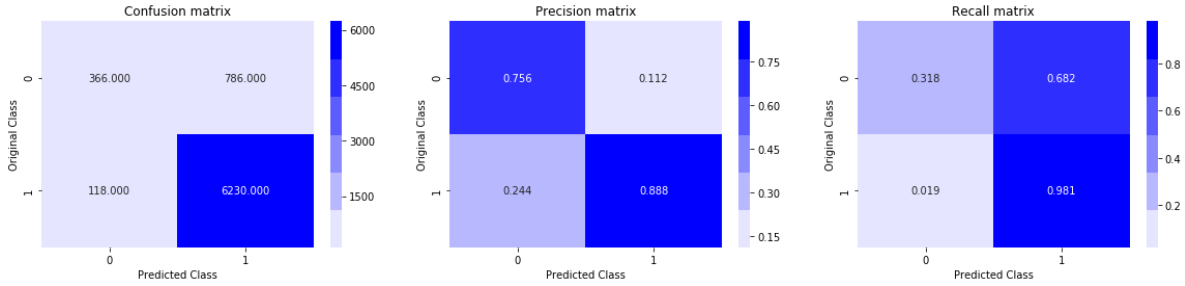
```
Best HyperParameter:  {'max_depth': 130, 'n_estimators': 10}
0.8483462681980961
```



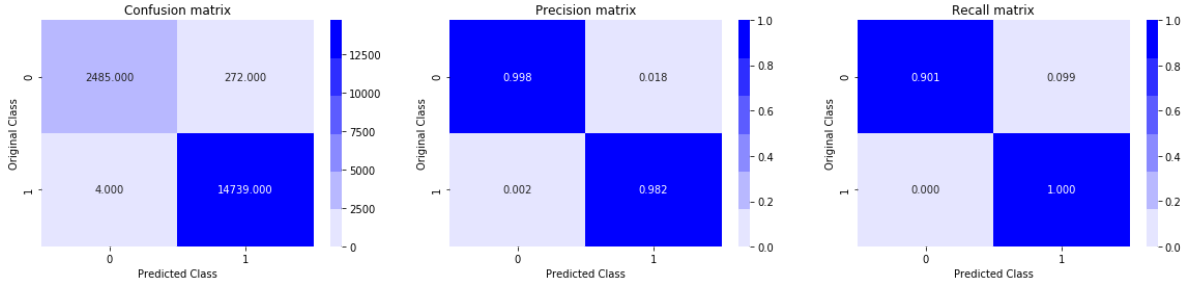
In [23]:

```
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
rf = RandomForestClassifier(n_estimators=optimal_learners,max_depth=optimal_depth, max_feat
rf.fit(X_train_vec,Y_train)
Y_pred = rf.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = rf.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
f1score= f1_score(Y_train, y_train_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter depth = 10 is:  87.946667%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8578714371127336
precision score  for   the model is: 0.8879703534777651
```



```
Accuracy of the model at optimal hyperparameter depth = 10 is:  98.422857%
f1 score value for   the model is: 0.9838967456985855
precision score  for   the model is: 0.9818799546998868
```

Gradient Boosting Decision Tree(GBDT) with GridSearchCV

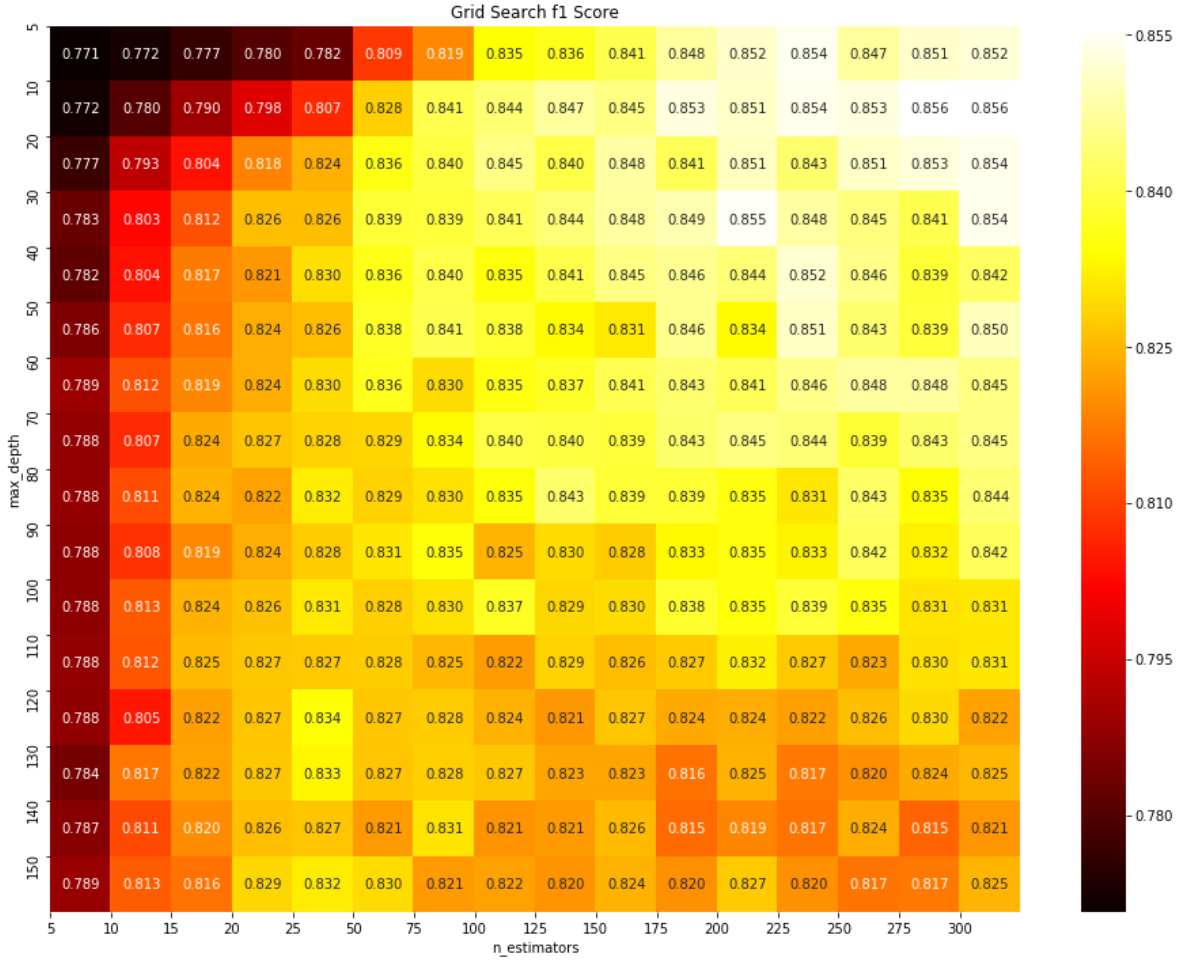
In [24]:

```
base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]
depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]

param_grid = {'n_estimators': base_learners,  'max_depth': depth}
GBC = GradientBoostingClassifier(max_features='sqrt',subsample=0.1)
model = GridSearchCV(GBC, param_grid, scoring = 'f1_weighted', cv=3 , n_jobs = -1,pre_dispa
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

# Optimal value of depth
optimal_depth = model.best_estimator_.max_depth
print("\nThe optimal value of depth is : ",optimal_depth)
```

```
Model with best parameters :
 GradientBoostingClassifier(criterion='friedman_mse', init=None,
              learning_rate=0.1, loss='deviance', max_depth=10,
              max_features='sqrt', 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=275,
              n_iter_no_change=None, presort='auto', random_state=None,
              subsample=0.1, tol=0.0001, validation_fraction=0.1,
              verbose=0, warm_start=False)
Accuracy of the model :  0.868906442646433
The optimal number of base learners is :  275

The optimal value of depth is :  10
```

In [25]:

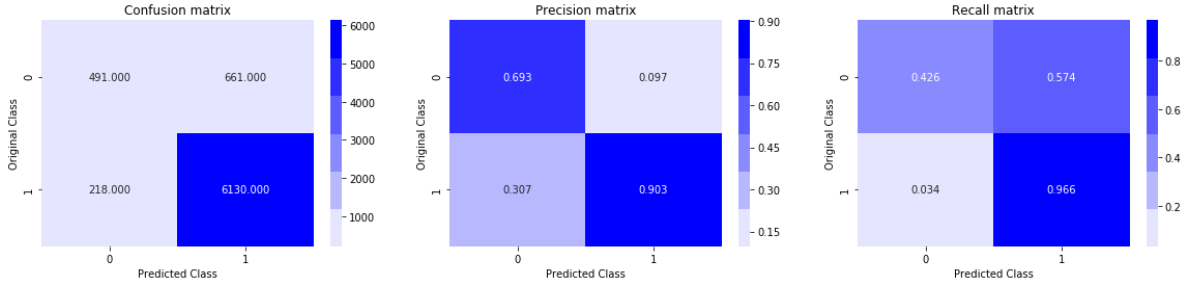
```
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```



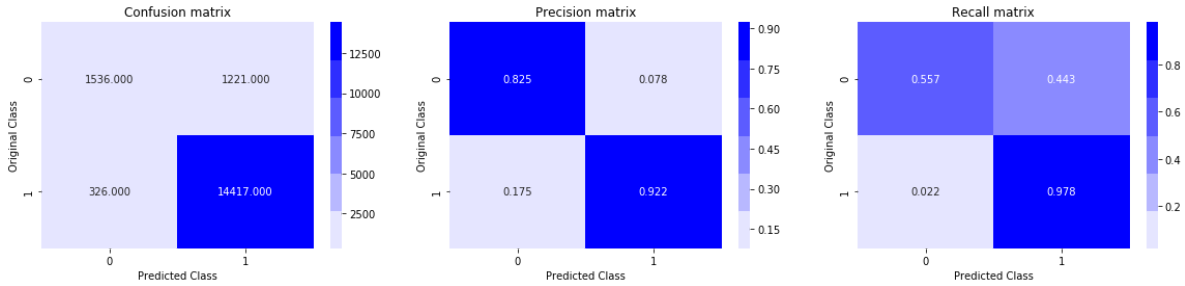
In [26]:

```
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
gb = GradientBoostingClassifier(n_estimators=optimal_learners, max_depth=optimal_depth, max
gb.fit(X_train_vec,Y_train)
Y_pred = gb.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = gb.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
f1score= f1_score(Y_train, y_train_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter estimator = 275 is:  88.2800
00%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8708263999703252
precision score  for   the model is: 0.9026652922986306
```




```
Accuracy of the model at optimal hyperparameter estimator = 275 is:  91.1600
00%
f1 score value for   the model is: 0.9043376888246839
precision score  for   the model is: 0.9219209617598159
```

Average Word2Vec

In [27]:

```
# List of sentence in X_train text
sent_of_train=[]
for sent in X_train:
    sent_of_train.append(sent.split())

# List of sentence in X_est text
sent_of_test=[]
for sent in X_test:
    sent_of_test.append(sent.split())

# Train your own Word2Vec model using your own train text corpus
# min_count = 5 considers only words that occured atleast 5 times
w2v_model=Word2Vec(sent_of_train,min_count=5,size=50, workers=4)

w2v_words = list(w2v_model.wv.vocab)
print("number of words that occured minimum 5 times ",len(w2v_words))
```

```
number of words that occured minimum 5 times  5870
```

In [28]:

```
# compute average word2vec for each review for X_train .
train_vectors = [];
for sent in sent_of_train:
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent: #
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    train_vectors.append(sent_vec)
```

In [29]:

```
# compute average word2vec for each review for X_test .
test_vectors = [];
for sent in sent_of_test:
    sent_vec = np.zeros(50)
    cnt_words =0;
    for word in sent: #
        if word in w2v_words:
            vec = w2v_model.wv[word]
            sent_vec += vec
            cnt_words += 1
    if cnt_words != 0:
        sent_vec /= cnt_words
    test_vectors.append(sent_vec)

X_train_vec = train_vectors
X_test_vec = test_vectors
```

Random Forest(RF) with GridSearchCV

In [30]:

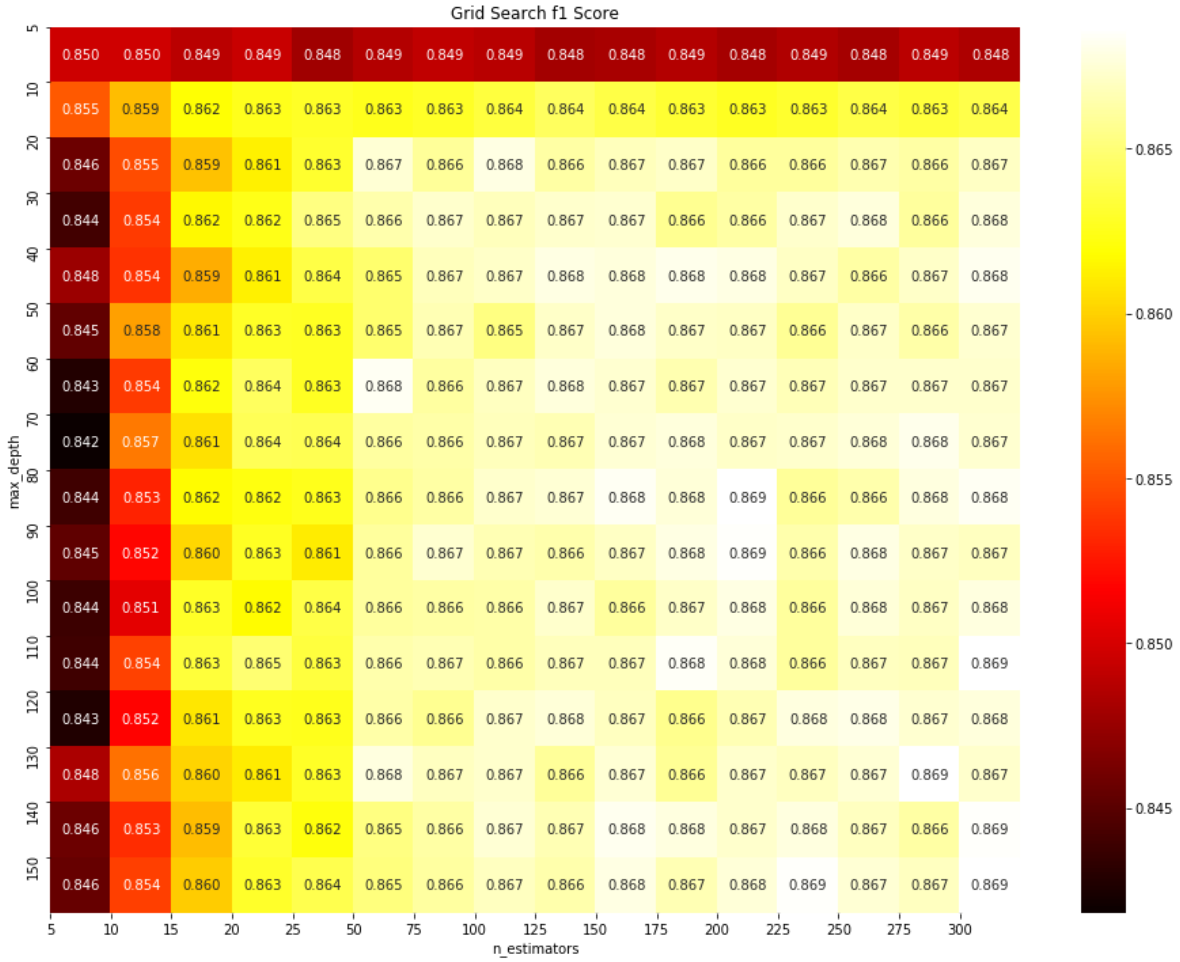
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import GridSearchCV
from sklearn.metrics import accuracy_score,confusion_matrix,f1_score,precision_score,recall
base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]

depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]
param_grid = {'n_estimators': base_learners,'max_depth': depth}
RFC = RandomForestClassifier(max_features=0.2)
model = GridSearchCV(RFC, param_grid, scoring = 'f1_micro', cv=3 , n_jobs = -1,pre_dispatch
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

optimal_depth=model.best_estimator_.max_depth
print("The optimal number of depth is : ",optimal_depth)
```

```
Model with best parameters :
 RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=80, max_features=0.2, 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=200, n_jobs=None,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
Accuracy of the model :  0.8716000000000002
The optimal number of base learners is :  200
The optimal number of depth is :  80
```

In [32]:

```
print("Best HyperParameter: ",model.best_params_)
print(model.best_score_)
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```

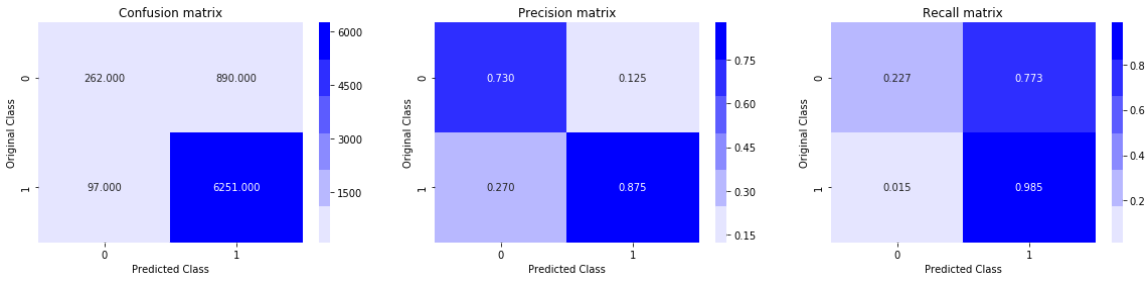
```
Best HyperParameter:  {'max_depth': 80, 'n_estimators': 200}
0.8686857142857143
```



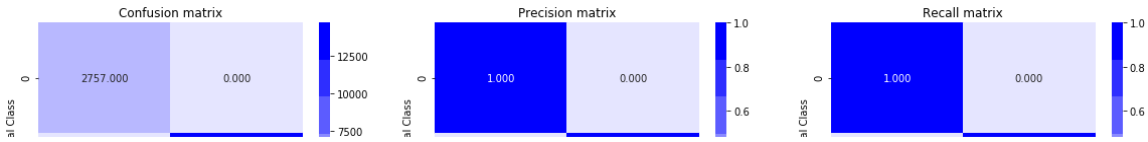
In [33]:

```
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
rf = RandomForestClassifier(n_estimators=optimal_learners,max_depth=optimal_depth, max_feat
rf.fit(X_train_vec,Y_train)
Y_pred = rf.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='micro')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = rf.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
f1score= f1_score(Y_train, y_train_pred, average='micro')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter depth = 200 is:  86.84000
0%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8684
precision score  for   the model is: 0.8753675955748494
```



Gradient Boosting Decision Tree(GBDT) with GridSearchCV

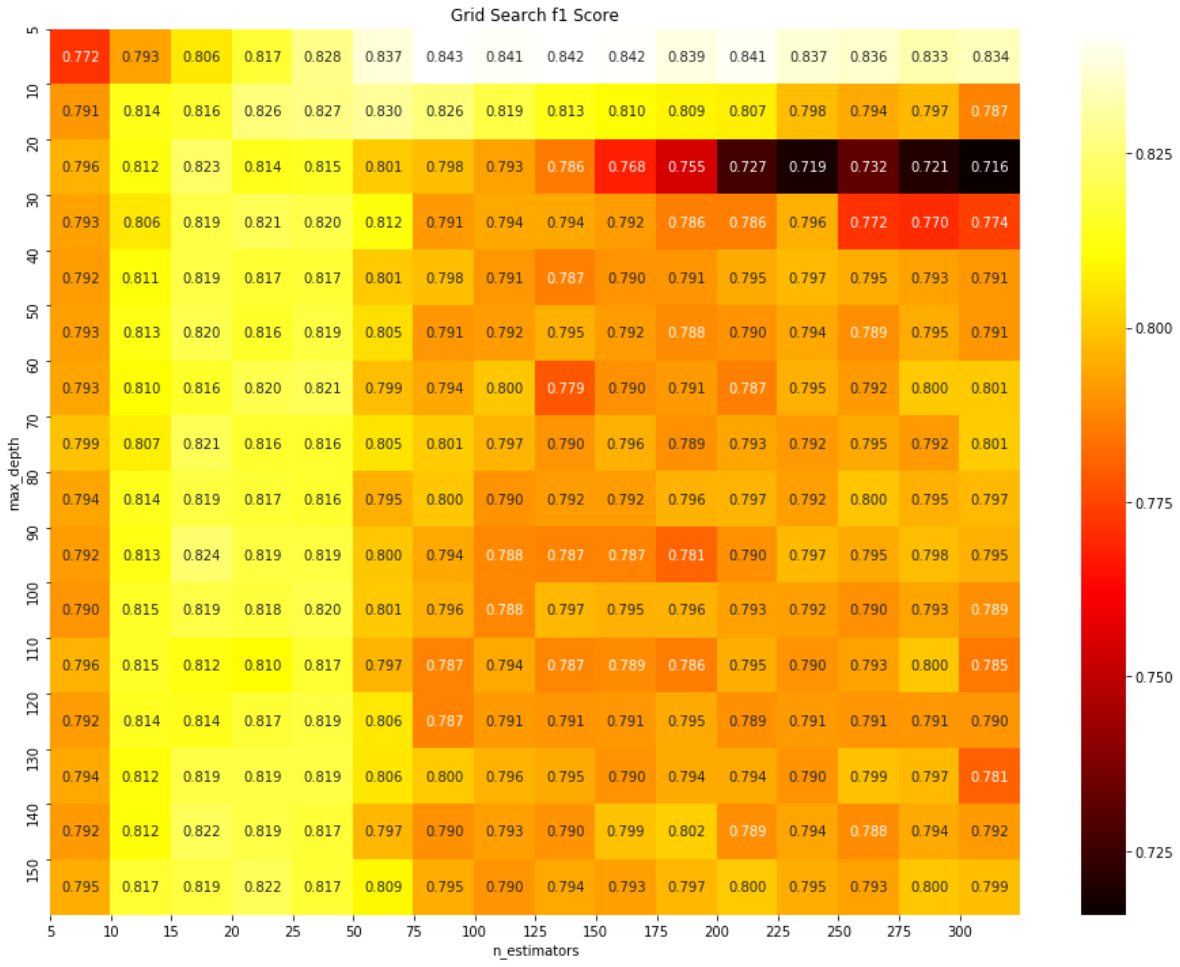
In [34]:

```
from sklearn.ensemble import GradientBoostingClassifier
base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]
depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]

param_grid = {'n_estimators': base_learners,  'max_depth': depth}
GBC = GradientBoostingClassifier(max_features='sqrt',subsample=0.1)
model = GridSearchCV(GBC, param_grid, scoring = 'f1_weighted', cv=3 , n_jobs = -1,pre_dispa
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

# Optimal value of depth
optimal_depth = model.best_estimator_.max_depth
print("\nThe optimal value of depth is : ",optimal_depth)
```

```
Model with best parameters :
 GradientBoostingClassifier(criterion='friedman_mse', init=None,
              learning_rate=0.1, loss='deviance', max_depth=5,
              max_features='sqrt', 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=75,
              n_iter_no_change=None, presort='auto', random_state=None,
              subsample=0.1, tol=0.0001, validation_fraction=0.1,
              verbose=0, warm_start=False)
Accuracy of the model :  0.8457429290695962
The optimal number of base learners is :  75

The optimal value of depth is :  5
```

In [35]:

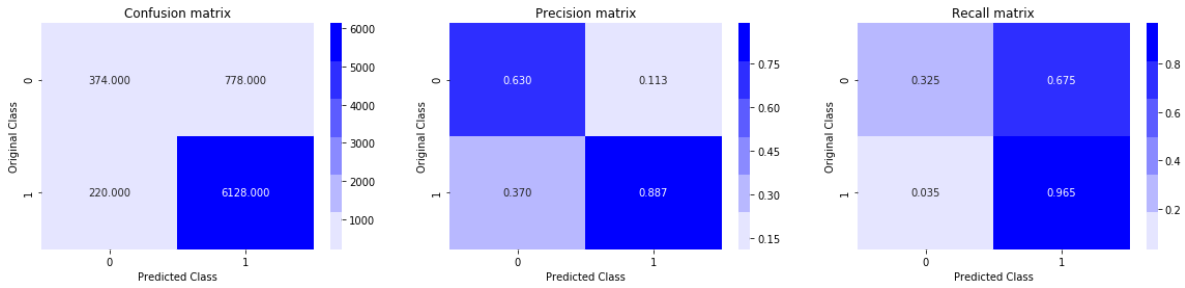
```
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```



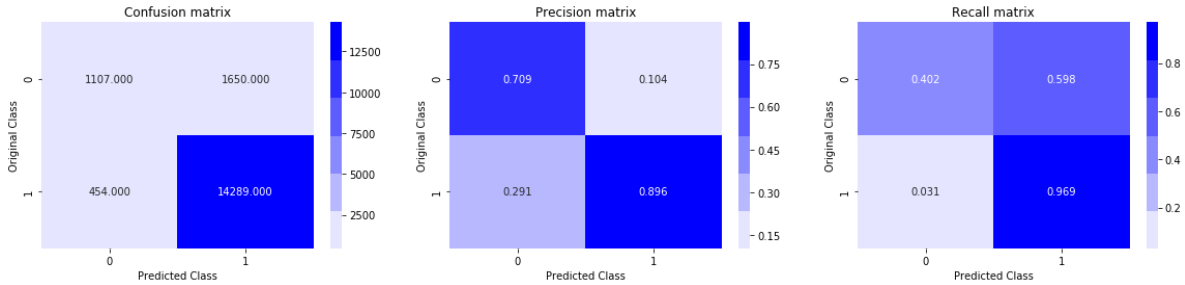
In [36]:

```
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
gb = GradientBoostingClassifier(n_estimators=optimal_learners, max_depth=optimal_depth, max
gb.fit(X_train_vec,Y_train)
Y_pred = gb.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = gb.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
f1score= f1_score(Y_train, y_train_pred, average='weighted')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter estimator = 75 is:  86.69333
3%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8484711895572471
precision score  for   the model is: 0.8873443382565884
```




```
Accuracy of the model at optimal hyperparameter estimator = 75 is:  87.97714
3%
f1 score value for   the model is: 0.8654642542025487
precision score  for   the model is: 0.8964803312629399
```

TFIDF-Word2Vec

In [37]:

```
# TF-IDF weighted Word2Vec
tf_idf_vect = TfidfVectorizer()

# final_tf_idf1 is the sparse matrix with row= sentence, col=word and cell_val = tfidf
final_tf_idf1 = tf_idf_vect.fit_transform(X_train)

# tfidf words/col-names
tfidf_feat = tf_idf_vect.get_feature_names()

# compute TFIDF Weighted Word2Vec for each review for X_test .
tfidf_test_vectors = [];
row=0;
for sent in sent_of_test:
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = final_tf_idf1[row, tfidf_feat.index(word)]
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidf_test_vectors.append(sent_vec)
    row += 1
```

In [38]:

```
# compute TFIDF Weighted Word2Vec for each review for X_train .
tfidf_train_vectors = [];
row=0;
for sent in sent_of_train:
    sent_vec = np.zeros(50)
    weight_sum =0;
    for word in sent:
        if word in w2v_words:
            vec = w2v_model.wv[word]
            # obtain the tf_idfidf of a word in a sentence/review
            tf_idf = final_tf_idf1[row, tfidf_feat.index(word)]
            sent_vec += (vec * tf_idf)
            weight_sum += tf_idf
    if weight_sum != 0:
        sent_vec /= weight_sum
    tfidf_train_vectors.append(sent_vec)
    row += 1

X_train_vec = tfidf_train_vectors
X_test_vec = tfidf_test_vectors
```

Random Forest(RF) with GridSearchCV

In [39]:

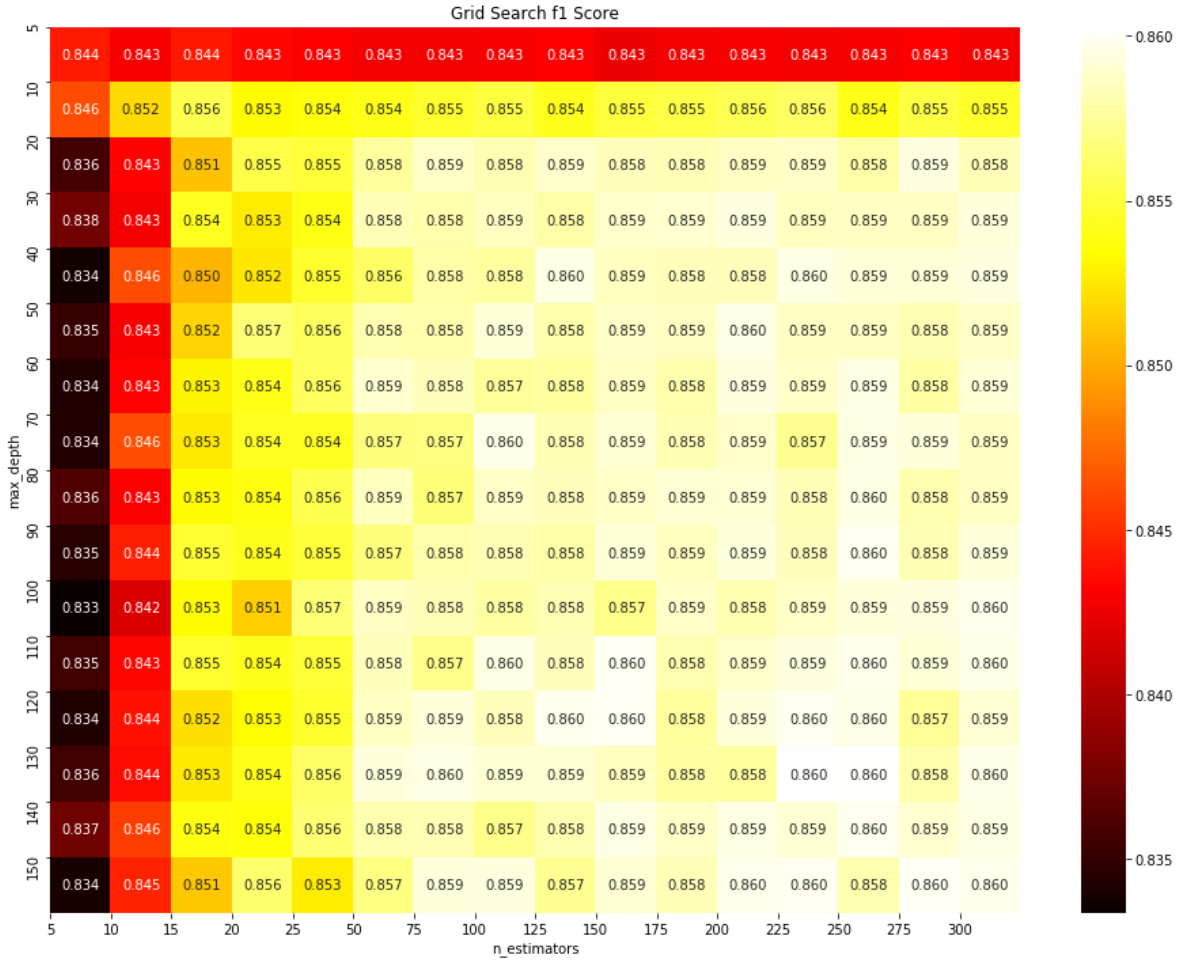
```
base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]

depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]
param_grid = {'n_estimators': base_learners,'max_depth': depth}
RFC = RandomForestClassifier(max_features='sqrt')
model = GridSearchCV(RFC, param_grid, scoring = 'f1_micro', cv=3 , n_jobs = -1,pre_dispatch
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

optimal_depth=model.best_estimator_.max_depth
print("The optimal number of depth is : ",optimal_depth)
```

```
Model with best parameters :
 RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=130, max_features='sqrt', 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=225, n_jobs=None,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
Accuracy of the model :  0.8050666666666666
The optimal number of base learners is :  225
The optimal number of depth is :  130
```

In [40]:

```
print("Best HyperParameter: ",model.best_params_)
print(model.best_score_)
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```

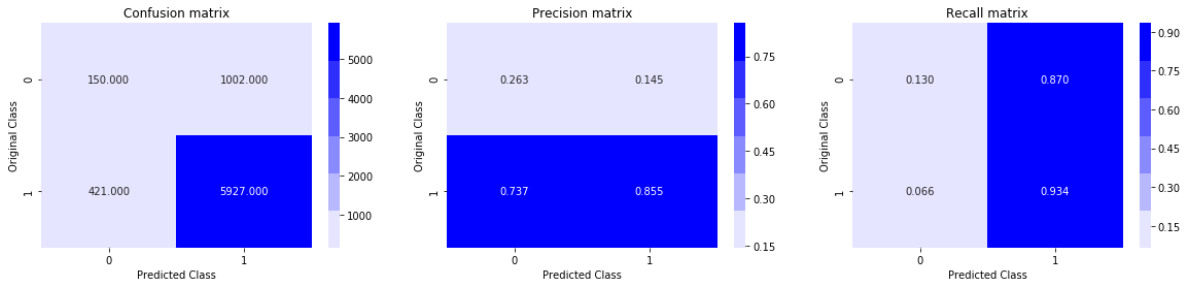
```
Best HyperParameter:  {'max_depth': 130, 'n_estimators': 225}
0.8602857142857143
```



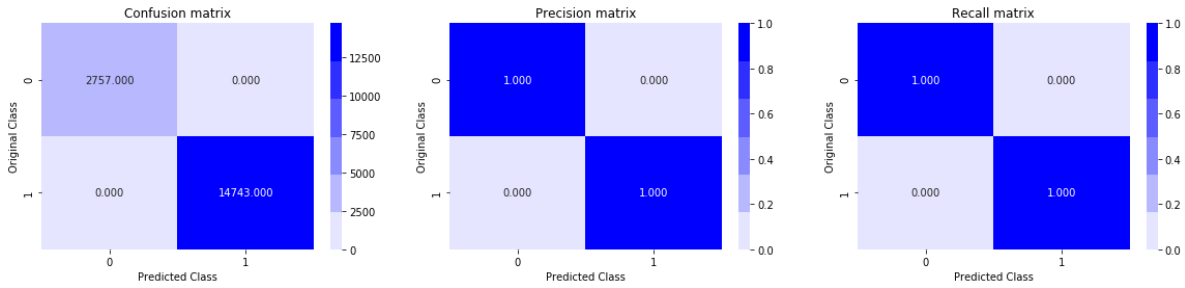
In [41]:

```
#confusion matrix,precision matrix,recall matrix,accuracy
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
rf = RandomForestClassifier(n_estimators=optimal_learners,max_depth=optimal_depth, max_feat
rf.fit(X_train_vec,Y_train)
Y_pred = rf.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='micro')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = rf.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter depth = %d is:  %f%%' % (optimal_lea
f1score= f1_score(Y_train, y_train_pred, average='micro')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter depth = 225 is:  81.026667%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.8102666666666667
precision score  for   the model is: 0.8553903882234088
```




```
Accuracy of the model at optimal hyperparameter depth = 225 is:  100.000000%
f1 score value for   the model is: 1.0
precision score  for   the model is: 1.0
```

Gradient Boosting Decision Tree(GBDT) with

GridSearchCV

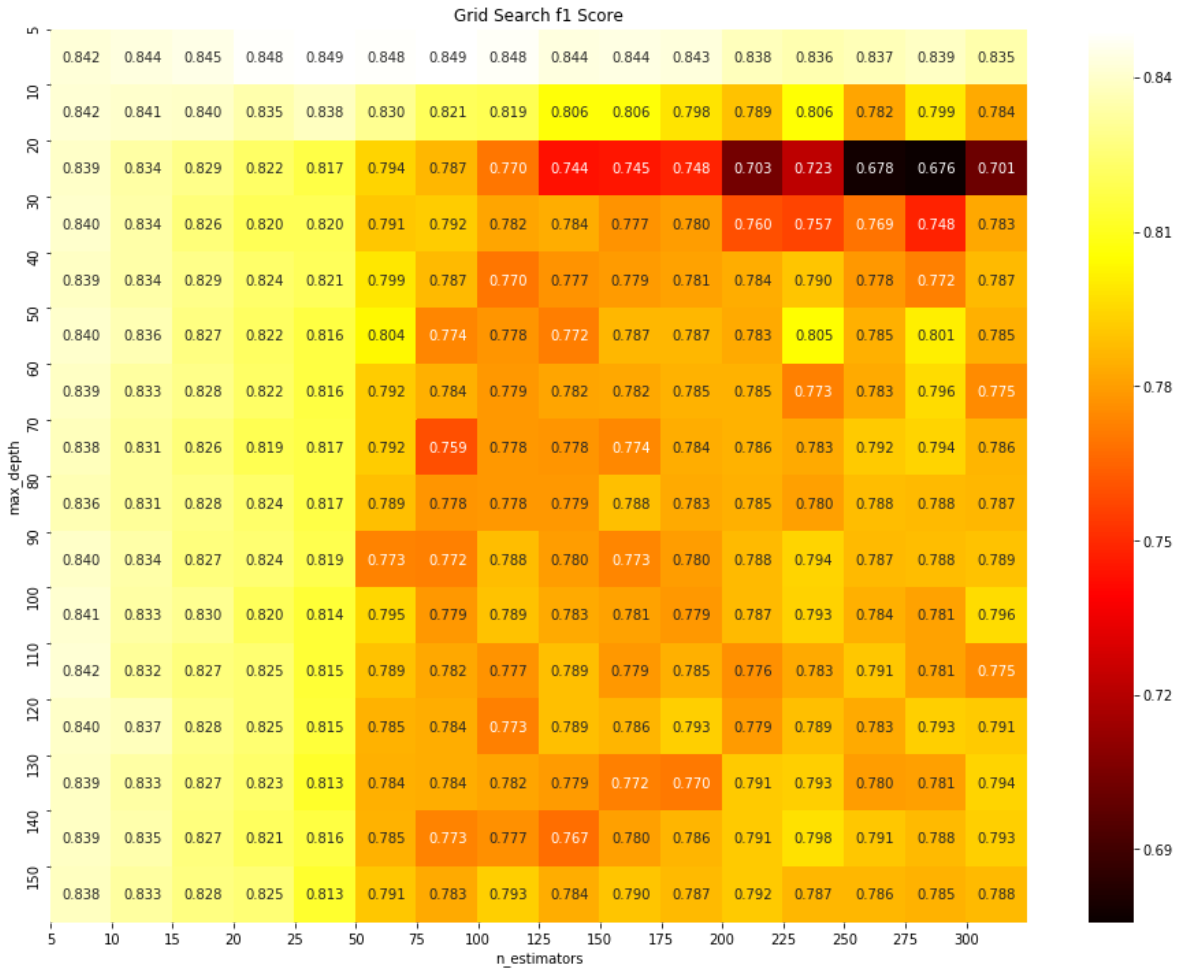
In [42]:

```
base_learners = [5,10,15,20,25,50,75,100,125,150,175,200,225,250,275,300]
depth = [5,10,20,30,40,50,60,70,80,90,100,110,120,130,140,150]

param_grid = {'n_estimators': base_learners,  'max_depth': depth}
GBC = GradientBoostingClassifier(max_features='sqrt',subsample=0.1)
model = GridSearchCV(GBC, param_grid, scoring = 'f1_micro', cv=3 , n_jobs = -1,pre_dispatch
model.fit(X_train_vec, Y_train)
print("Model with best parameters :\n",model.best_estimator_)
print("Accuracy of the model : ",model.score(X_test_vec, Y_test))

# Optimal value of number of base learners
optimal_learners = model.best_estimator_.n_estimators
print("The optimal number of base learners is : ",optimal_learners)

# Optimal value of depth
optimal_depth = model.best_estimator_.max_depth
print("\nThe optimal value of depth is : ",optimal_depth)
```

```
Model with best parameters :
 GradientBoostingClassifier(criterion='friedman_mse', init=None,
              learning_rate=0.1, loss='deviance', max_depth=5,
              max_features='sqrt', 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=25,
              n_iter_no_change=None, presort='auto', random_state=None,
              subsample=0.1, tol=0.0001, validation_fraction=0.1,
              verbose=0, warm_start=False)
Accuracy of the model :  0.7290666666666666
The optimal number of base learners is :  25

The optimal value of depth is :  5
```

In [43]:

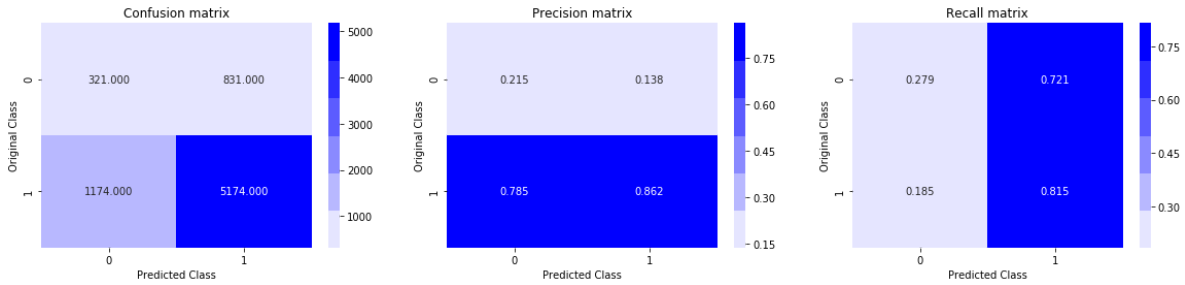
```
scores = model.cv_results_['mean_test_score'].reshape(len(base_learners),len(depth))

plt.figure(figsize=(16, 12))
sns.heatmap(scores, annot=True, cmap=plt.cm.hot, fmt=".3f", xticklabels=base_learners, ytic
plt.xlabel('n_estimators')
plt.ylabel('max_depth')
plt.xticks(np.arange(len(base_learners)), base_learners)
plt.yticks(np.arange(len(depth)), depth)
plt.title('Grid Search f1 Score')
plt.show()
```



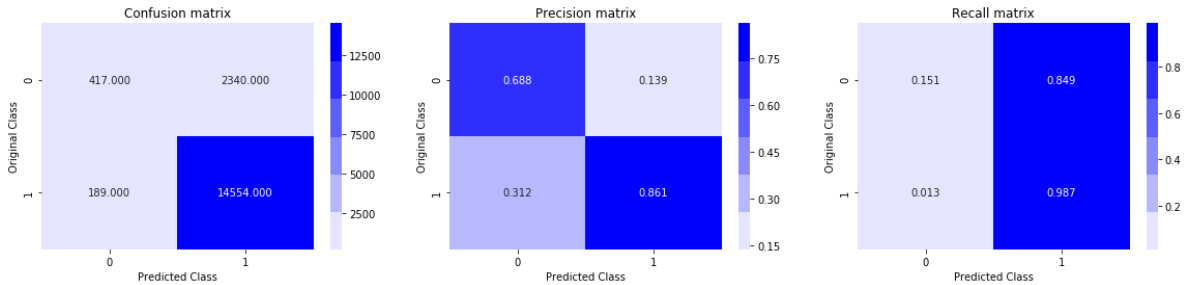
In [44]:

```
from sklearn.metrics import accuracy_score, precision_recall_fscore_support, f1_score
gb = GradientBoostingClassifier(n_estimators=optimal_learners, max_depth=optimal_depth, max
gb.fit(X_train_vec,Y_train)
Y_pred = gb.predict(X_test_vec)
Y_test_accuracy = accuracy_score(Y_test, Y_pred, normalize=True, sample_weight=None)*100
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
print('Confusion matrix for the model is:')
plot_confusion_matrix(Y_test, Y_pred)
f1score= f1_score(Y_test, Y_pred, average='micro')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_test, Y_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
y_train_pred = gb.predict(X_train_vec)
Y_train_accuracy =accuracy_score(Y_train, y_train_pred, normalize=True, sample_weight=None)
plot_confusion_matrix(Y_train, y_train_pred)
print('Accuracy of the model at optimal hyperparameter estimator = %d is:  %f%%' % (optimal
f1score= f1_score(Y_train, y_train_pred, average='micro')
print('f1 score value for   the model is: %s'% f1score)
precisionscore=precision_score(Y_train, y_train_pred,pos_label='positive' )
print('precision score  for   the model is: %s'% precisionscore)
```

```
Accuracy of the model at optimal hyperparameter estimator = 25 is:  73.26666
7%
Confusion matrix for the model is:
```




```
f1 score value for   the model is: 0.7326666666666668
precision score  for   the model is: 0.8616153205661948
```




```
Accuracy of the model at optimal hyperparameter estimator = 25 is:  85.54857
1%
f1 score value for   the model is: 0.8554857142857143
precision score  for   the model is: 0.8614892861370901
```

In [49]:

```
from prettytable import PrettyTable

# Names of models
featurization = ['Bag of Words','Bag of Words','TFIDF ','TFIDF ','avg w2v','avg w2vw','TFID
model=['Random Forest(RF)  ','Gradient Boosting Decision Tree','Random Forest(RF)  ','Gradi



baselearners =[10,300,10,275,200,75,225,25]
depth=[120,20,130,10,80,5,130,5]
accuracy = [87.77,86.96,87.94,88.28,86.84,86.69,81.02,73.26]
F1score= [0.8631,0.8635,0.8578,0.8708,0.8684,0.8484,0.8102,0.7326]
precision=[0.8965,0.9083,0.8879,0.9026,0.8753,0.8873,0.8553,0.8616]
numbering = [1,2,3,4,5,6,7,8]

# Initializing prettytable
ptable = PrettyTable()

# Adding columns
ptable.add_column("S.NO.",numbering)
ptable.add_column("MODEL",featurization)
ptable.add_column("Method",model)
ptable.add_column("base learners",baselearners)
ptable.add_column("depth",depth)
ptable.add_column("accuracy",accuracy)
ptable.add_column("f1score",F1score)
ptable.add_column("precision",precision)

# Printing the Table
print(ptable)
```

```
+-------+-------------------------+---------------------------------+-------
--------+-------+----------+---------+-----------+
| S.NO. |          MODEL          |              Method             | base l
earners | depth | accuracy | f1score | precision |
+-------+-------------------------+---------------------------------+-------
--------+-------+----------+---------+-----------+
|   1   |       Bag of Words      |       Random Forest(RF)         |
10      |  120  |  87.77   |  0.8631 |   0.8965  |
|   2   |       Bag of Words      | Gradient Boosting Decision Tree |      3
00      |   20  |  86.96   |  0.8635 |   0.9083  |
|   3   |          TFIDF          |       Random Forest(RF)         |
10      |  130  |  87.94   |  0.8578 |   0.8879  |
|   4   |          TFIDF          | Gradient Boosting Decision Tree |      2
75      |   10  |  88.28   |  0.8708 |   0.9026  |
|   5   |         avg w2v         |       Random Forest(RF)         |      2
00      |   80  |  86.84   |  0.8684 |   0.8753  |
|   6   |         avg w2vw        | Gradient Boosting Decision Tree |
75      |   5   |  86.69   |  0.8484 |   0.8873  |
|   7   | TFIDF weighted word2vec |       Random Forest(RF)         |      2
25      |  130  |  81.02   |  0.8102 |   0.8553  |
|   8   | TFIDF weighted word2vec | Gradient Boosting Decision Tree |
25      |   5   |  73.26   |  0.7326 |   0.8616  |
+-------+-------------------------+---------------------------------+-------
--------+-------+----------+---------+-----------+
```

In [ ]:

```

```

In [ ]:

```

```

In [ ]:

```

```