Decision Tree on Amazon food reviews data set

June 6, 2018

0.0.1 Decision Tree on Amazon food reviews data set

```
In [1]: #importing required Modules
        %matplotlib inline
        import sqlite3
        import pandas as pd
        import numpy as np
        import nltk
        import string
        import pickle
        import matplotlib.pyplot as plt
        import seaborn as sns
        from sklearn.feature_extraction.text import TfidfTransformer
        from sklearn.feature_extraction.text import TfidfVectorizer
        from sklearn.feature_extraction.text import CountVectorizer
        from sklearn.metrics import confusion_matrix
        from sklearn import metrics
        from sklearn.metrics import accuracy_score
        from sklearn.metrics import roc_curve, auc
        from nltk.stem.porter import PorterStemmer
        from sklearn.preprocessing import StandardScaler
        from sklearn.model_selection import TimeSeriesSplit
        from sklearn.metrics import precision_score
        from sklearn.metrics import recall_score
        from sklearn.metrics import confusion_matrix
        from sklearn.tree import DecisionTreeClassifier as DT
        from sklearn.model_selection import GridSearchCV
        from sklearn.model_selection import RandomizedSearchCV
        import warnings
        warnings.filterwarnings('ignore')
```

```
In [2]: #getting cleaned data from db
        conn = sqlite3.connect('final_clean_LR.sqlite')
        final_review = pd.read_sql_query("""
        SELECT *
        FROM Reviews_final
        """, conn)
```

```
In [3]: #SORT by time for TBS
        final_review = final_review.sort_values(by='Time')
```

```
In [4]: #info of data
        final_review.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 364171 entries, 23 to 345187
Data columns (total 15 columns):
level_0                    364171 non-null int64
index                      364171 non-null int64
Id                         364171 non-null int64
ProductId                  364171 non-null object
UserId                     364171 non-null object
ProfileName                364171 non-null object
HelpfulnessNumerator       364171 non-null int64
HelpfulnessDenominator     364171 non-null int64
Score                      364171 non-null object
Time                       364171 non-null int64
Summary                    364171 non-null object
Text                       364171 non-null object
CleanedTextBow             364171 non-null object
final_text                 364171 non-null object
final_stem_text            364171 non-null object
dtypes: int64(6), object(9)
memory usage: 44.5+ MB
```

```
In [5]: #changing lables to 1 or 0
        final_review.Score = final_review.Score.apply(lambda x:
                                    1 if x == 'positive' else 0)
```

```
In [6]: #Converting to int8
        final_review.HelpfulnessNumerator = final_review.\
                                      HelpfulnessNumerator.astype(np.int8)
        final_review.HelpfulnessDenominator = final_review.\
                                      HelpfulnessDenominator.astype(np.int8)
```

```
In [7]: #Splitting Dataframe for train and test
        train_df = final_review.iloc[:round(final_review.shape[0]*0.70),:]
        test_df = final_review.iloc[round(final_review.shape[0]*0.70):,:]
```

```
In [8]: train_df.to_csv('train_df_dt.csv',index=False)
        test_df.to_csv('test_df_dt.csv',index=False)
```

```
In [8]: print(train_df.shape)
        print(test_df.shape)
```

```
(254920, 15)
(109251, 15)
```

Word2Vec

```
In [9]: #importing
        from gensim.models import Word2Vec
        from gensim.models import KeyedVectors
        import pickle
        import gensim
```

```
In [10]: import gensim
         list_of_sent=[]
         for sent in final_review.final_text.values:
             list_of_sent.append(sent.split())
```

```
In [13]: #word2vec model with 50 dim vector
         w2v_model_50=gensim.models.Word2Vec(list_of_sent,min_count=5,size=50, workers=8)
         #word2vec model with 100 dim vector
         w2v_model_100=gensim.models.Word2Vec(list_of_sent,min_count=5,size=100, workers=8)
         #word2vec model with 300 dim vector
         w2v_model_300=gensim.models.Word2Vec(list_of_sent,min_count=5,size=300, workers=8)
```

```
In [14]: #saving to disk
         pickle.dump(w2v_model_50,open('w2v_model_dt_50.p','wb'))
         pickle.dump(w2v_model_100,open('w2v_model_dt_100.p','wb'))
         pickle.dump(w2v_model_300,open('w2v_model_dt_300.p','wb'))
```

```
In [11]: #loading from disk
         w2v_model_100 = pickle.load(open('w2v_model_dt_100.p','rb'))
         w2v_model_50 = pickle.load(open('w2v_model_dt_50.p','rb'))
         w2v_model_300 = pickle.load(open('w2v_model_dt_300.p','rb'))
```

Avg Word2Vec

```
In [13]: # the avg-w2v for each sentence/review is stored in this list
         def avg_w2v(list_of_sent,model,d):
             '''
             Returns average of word vectors for
             each sentance with dimension of model given
             '''
             sent_vectors = []
             for sent in list_of_sent: # for each review/sentence
                 doc = [word for word in sent if word in model.wv.vocab]
                 if doc:
                     sent_vec = np.mean(model.wv[doc],axis=0)
                 else:
                     sent_vec = np.zeros(d)
                 sent_vectors.append(sent_vec)
             return sent_vectors
```

```
In [17]: list_of_sent_train=[]
         for sent in train_df.final_text.values:
             list_of_sent_train.append(sent.split())
```

```
In [18]: #avg word2vec for
         sent_vector_avgw2v_300 = avg_w2v(list_of_sent_train,w2v_model_300,300)
         #stacking columns
         train_avgw2v_300 = np.hstack((sent_vector_avgw2v_300,
                     train_df[['HelpfulnessNumerator','HelpfulnessDenominator','Score']]))
         column = list(range(0,300))
         column.extend(['HelpfulnessNumerator','HelpfulnessDenominator','Score'])
         train_df_avgw2v_300 = pd.DataFrame(train_avgw2v_300,columns=column)
```

```
In [19]: #CountVectorizer for BoW
         X_train = train_df_avgw2v_300.iloc[:round(train_df.shape[0]*0.70),:]
         X_test_cv = train_df_avgw2v_300.iloc[round(train_df.shape[0]*0.70):,:]
```

```
In [32]: model = DT().fit(X_train.drop('Score',axis=1),X_train.Score)
         #train score
         train_score = model.score(X_train.drop('Score',axis=1),X_train.Score)
         #test score
         test_score = model.score(X_test_cv.drop('Score',axis=1),X_test_cv.Score)
         print('Train Score',train_score)
         print('Test Score',test_score)
```

```
Train Score 1.0
Test Score 0.8445786913541503
```

With max depth i got model which was so much overfit.

```
In [44]: for i in [1,2,3,4,5,6,7,8,9,10,11,12]:
             model = DT(max_depth=i).fit(X_train.drop('Score',axis=1),X_train.Score)
             #train score
             train_score = model.score(X_train.drop('Score',axis=1),X_train.Score)
             #test score
             test_score = model.score(X_test_cv.drop('Score',axis=1),X_test_cv.Score)
             print('Depth',i,'Train Score',train_score,'Test Score',test_score)
```

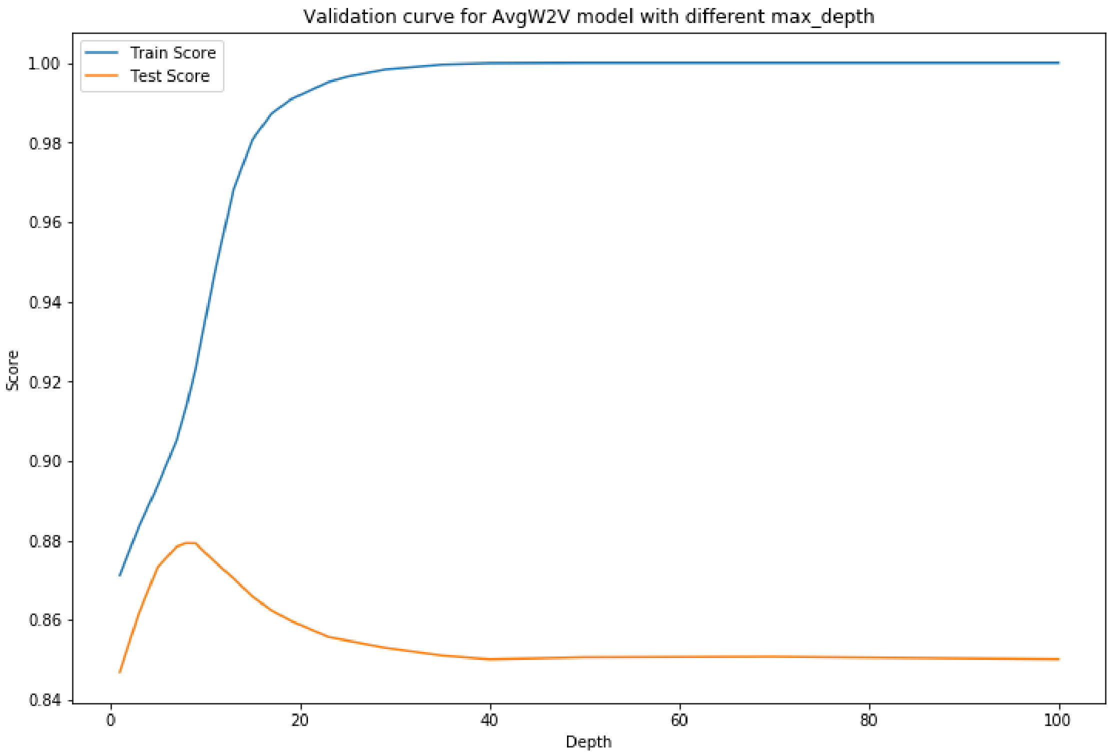
```
Depth 1 Train Score 0.8600121046378696 Test Score 0.8293451540352529
Depth 2 Train Score 0.8687543430992356 Test Score 0.8472854228777655
Depth 3 Train Score 0.8734560982717267 Test Score 0.8435979915267535
Depth 4 Train Score 0.8796765371769295 Test Score 0.8608713844866364
Depth 5 Train Score 0.8846248683060232 Test Score 0.8601129766201161
Depth 6 Train Score 0.8893546434735827 Test Score 0.8662194675453737
Depth 7 Train Score 0.8938434466835534 Test Score 0.868612375124222
Depth 8 Train Score 0.9010501894151667 Test Score 0.8713452586432345
Depth 9 Train Score 0.909400147945574 Test Score 0.8704691667974267
Depth 10 Train Score 0.9212189818654591 Test Score 0.8698807469009886
Depth 11 Train Score 0.9341249915940015 Test Score 0.87024687483655
Depth 12 Train Score 0.947524153235749 Test Score 0.866664051467127
```

```
In [14]: param_grid = {'max_depth':[1,3,5,7,8,9,11,13,15,17,19,23,25,
                                           29,35,40,50,70,100]}
         model_grid_avgw2v = GridSearchCV(DT(),param_grid=param_grid,
                                      cv=TimeSeriesSplit(n_splits=10),
                                                    n_jobs=-1)
         model_grid_avgw2v.fit(train_df_avgw2v_300.drop('Score',axis=1),
                                                train_df_avgw2v_300.Score)
```

```
In [16]: dict_scores = []
         idx = 0
         for i in model_grid_avgw2v.grid_scores_:
             dict_score = []
             dict_score.append(i[0]['max_depth'])
             dict_score.append(i[1])
             dict_score.append(i[2].std())
             dict_score.append(model_grid_avgw2v.cv_results_['mean_train_score'][idx])
             dict_scores.append(dict_score)
             idx = idx + 1
         scores_df = pd.DataFrame(dict_scores,columns=['depth','Test_score',
                                                        'Test_std','Train_score'])
```

```
In [17]: plt.figure(figsize=(12,8))
         plt.plot(scores_df.depth,scores_df.Train_score,label='Train Score')
         plt.plot(scores_df.depth,scores_df.Test_score,label='Test Score')
         plt.title('Validation curve for AvgW2V model with different max_depth')
         plt.xlabel('Depth')
         plt.ylabel('Score')
         plt.legend()
```

```
Out[17]: <matplotlib.legend.Legend at 0x14e0df52be48>
```



```
In [18]: #top scores
         scores_df.sort_values('Test_score',ascending=False).head(5)
```

```
Out[18]:    depth  Test_score  Test_std  Train_score
         4      8    0.879296  0.009600     0.913345
         5      9    0.879253  0.008580     0.923057
         3      7    0.878424  0.010808     0.905153
         6     11    0.874696  0.006940     0.946930
         2      5    0.873255  0.013776     0.893709
```

From cross validation better depth is 8 with Test score of 0.879296.

```
In [19]: #testscore
         list_of_sent_train=[]
         for sent in train_df.final_text.values:
             list_of_sent_train.append(sent.split())
         #avg word2vec for
         sent_vector_avgw2v_300 = avg_w2v(list_of_sent_train,w2v_model_300,300)
         #stacking columns
         train_avgw2v_300 = np.hstack((sent_vector_avgw2v_300,
                     train_df[['HelpfulnessNumerator','HelpfulnessDenominator']]))
         column = list(range(0,300))
         column.extend(['HelpfulnessNumerator','HelpfulnessDenominator'])
```

```
train_df_avgw2v_300 = pd.DataFrame(train_avgw2v_300,columns=column)


list_of_sent_test=[]
for sent in test_df.final_text.values:
    list_of_sent_test.append(sent.split())
#avg word2vec for
sent_vector_avgw2v_300_test = avg_w2v(list_of_sent_test,w2v_model_300,300)
#stacking columns
test_avgw2v_300 = np.hstack((sent_vector_avgw2v_300_test,
            test_df[['HelpfulnessNumerator','HelpfulnessDenominator']]))
column = list(range(0,300))
column.extend(['HelpfulnessNumerator','HelpfulnessDenominator'])
test_df_avgw2v_300 = pd.DataFrame(test_avgw2v_300,columns=column)


model = DT(max_depth=8)
model.fit(train_df_avgw2v_300,train_df.Score)
#Predicting training data
train_list = model.predict(train_df_avgw2v_300)
#Accuracy score
score_train = accuracy_score(train_df.Score,train_list)
#predict test cv
test_list = model.predict(test_df_avgw2v_300)
#Accuracy score
score_test = accuracy_score(test_df.Score,test_list)
#precision
#precision
test_precision = precision_score(test_df.Score,test_list)
#recall
test_recall = recall_score(test_df.Score,test_list)
#confusion matrix
confusion_matrix_test = confusion_matrix(test_df.Score,test_list)
print('max_depth',8)
print('Train Score', score_train)
print('Test Score',score_test)
print('Test Precision',test_precision)
print('Test Recall',test_recall)
print('Test ConfusionMatrix',confusion_matrix_test)
```

```
max_depth 8
Train Score 0.8931115644123646
Test Score 0.8619692268262991
Test Precision 0.8777263581488933
Test Recall 0.9675509027192477
Test ConfusionMatrix [[ 6925 12154]
 [ 2926 87246]]
```

Tf-Idf Weighted Word2Vec

```
In [20]: from sklearn.base import BaseEstimator, TransformerMixin

         class TfidfWeightedWord2Vec(BaseEstimator, TransformerMixin):
             '''
             Class for Tfidf Weighted Word2Vec Calculations
             '''
             def __init__(self, word2vec):
                 self.word2vec = word2vec
                 self.word2weight = None
                 self.dim = word2vec.vector_size
                 self.tfidf = None

             def fit(self, X, y=None):
                 tfidf = TfidfVectorizer()
                 tfidf.fit(X[:,0])
                 self.tfidf = tfidf
                 #print(self.word2vec.wv.vocab.keys())
                 return self

             def tf_idf_W2V(self,feature_names,tf_idf_trans_arr,list_of_sent):
                 '''
                 tfidf weighted word2vec calculation
                 '''
                 import operator
                 dict_tfidf = {k: v for v, k in enumerate(feature_names)}
                 sent_vectors = []
                 i = 0
                 for sent in list_of_sent: # for each review/sentence
                     doc = [word for word in sent if word in self.word2vec.wv.vocab.keys()]
                     if doc:
                         #itemgetter
                         f = operator.itemgetter(*doc)
                         try:
                             #itemgetter from dict
                             final = f(dict_tfidf)
                             final = tf_idf_trans_arr[i,final]
                             #converting to dense
                             final = final.toarray()
                             #converting to diagnol matrix for multiplication
                             final= np.diag(final[0])
                             sent_vec = np.dot(final,np.array(self.word2vec.wv[doc]))
                             #tfidf weighted word to vec
                             sent_vec = np.sum(sent_vec,axis=0) / np.sum(final)
                         except:
                             sent_vec = np.zeros(self.dim)
                     else:
                         sent_vec = np.zeros(self.dim)
                     sent_vectors.append(sent_vec)
                     i = i+1
                 return sent_vectors

             def transform(self, X):
                 #transform data
                 tf_idf_trans_arr = self.tfidf.transform(X[:,0])
                 feature_names = self.tfidf.get_feature_names()
                 list_of_sent = []
                 for sent in X[:,0]:
                     list_of_sent.append(sent.split())
                 temp_vec = self.tf_idf_W2V(feature_names,tf_idf_trans_arr,list_of_sent)
                 temp_vec= np.hstack((temp_vec,X[:,[1,2]]))
                 return temp_vec

In [21]: # For simple cv
         #Train data
         X_train = train_df.iloc[:round(train_df.shape[0]*0.70),:]
         X_test_cv = train_df.iloc[round(train_df.shape[0]*0.70):,:]
         #transforming to tfidf weighted word2vec
         tfidfvect_w2v = TfidfWeightedWord2Vec(w2v_model_300)
         tfidfvect_w2v.fit(X_train[['final_text','HelpfulnessNumerator',
                                    'HelpfulnessDenominator']].values)
         X_train_tfw2v = tfidfvect_w2v.transform(X_train[['final_text',
                         'HelpfulnessNumerator','HelpfulnessDenominator']].values)
         X_cv_tfw2v = tfidfvect_w2v.transform(X_test_cv[['final_text',
                          'HelpfulnessNumerator','HelpfulnessDenominator']].values)

In [22]: for i in [1,2,3,4,5,6,7,8,9,10,11,12]:
             model = DT(max_depth=i).fit(X_train_tfw2v,X_train.Score)
             #train score
             train_score = model.score(X_train_tfw2v,X_train.Score)
             #test score
             test_score = model.score(X_cv_tfw2v,X_test_cv.Score)
             print('Depth',i,'Train Score',train_score,'Test Score',test_score)
```

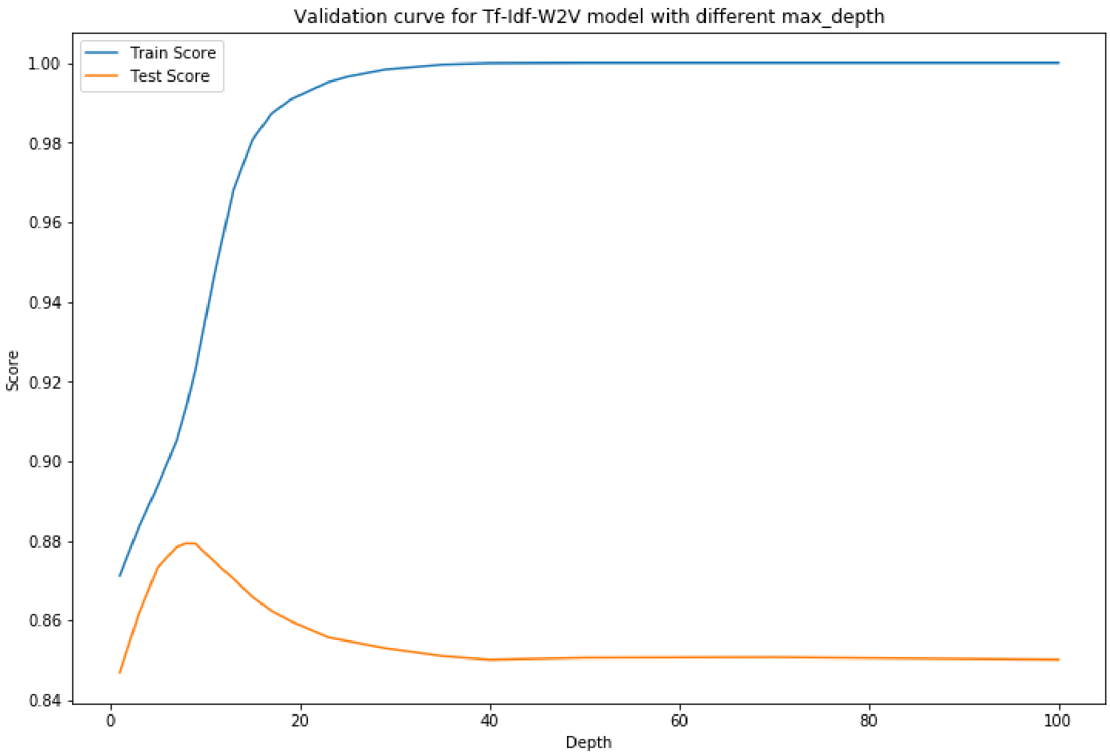
```
Depth 1 Train Score 0.8600121046378696 Test Score 0.8293451540352529
Depth 2 Train Score 0.8711360426800565 Test Score 0.8420288718029185
Depth 3 Train Score 0.8711360426800565 Test Score 0.8420288718029185
Depth 4 Train Score 0.8759330658357805 Test Score 0.848174590721272
Depth 5 Train Score 0.8803994530496962 Test Score 0.8514566661436268
Depth 6 Train Score 0.885218892201475 Test Score 0.8531565458444479
Depth 7 Train Score 0.8896068234291991 Test Score 0.8610936764475129
Depth 8 Train Score 0.8948017305148954 Test Score 0.8611590564360061
Depth 9 Train Score 0.9023391091883168 Test Score 0.8621920602541974
Depth 10 Train Score 0.9121461074622851 Test Score 0.8623620482242795
Depth 11 Train Score 0.9238192374078142 Test Score 0.8596945446937602
Depth 12 Train Score 0.9346349555042478 Test Score 0.857850829018254
```

```
In [23]: param_grid = {'decisiontreeclassifier__max_depth':[1,3,5,7,8,9,11,
                                   13,15,17,19,23,25,29,35,40,50,70,100]}
         model_grid_tfidfw2v = GridSearchCV(make_pipeline(
                             TfidfWeightedWord2Vec(w2v_model_300),DT()),
                             param_grid=param_grid,
                             cv=TimeSeriesSplit(n_splits=10),
                                 n_jobs=-1)
         model_grid_tfidfw2v.fit(train_df[['final_text','HelpfulnessNumerator',
                              'HelpfulnessDenominator']].values,train_df.Score)
```

```
In [26]: dict_scores = []
         idx = 0
         for i in model_grid_tfidfw2v.grid_scores_:
             dict_score = []
             dict_score.append(i[0]['decisiontreeclassifier__max_depth'])
             dict_score.append(i[1])
             dict_score.append(i[2].std())
             dict_score.append(model_grid_tfidfw2v.cv_results_['mean_train_score'][idx])
             dict_scores.append(dict_score)
             idx = idx + 1
         scores_df1 = pd.DataFrame(dict_scores,columns=['depth','Test_score',
                                                        'Test_std','Train_score'])
```

```
In [27]: plt.figure(figsize=(12,8))
         plt.plot(scores_df1.depth,scores_df.Train_score,label='Train Score')
         plt.plot(scores_df1.depth,scores_df.Test_score,label='Test Score')
         plt.title('Validation curve for Tf-Idf-W2V model with different max_depth')
         plt.xlabel('Depth')
         plt.ylabel('Score')
         plt.legend()
```

```
Out[27]: <matplotlib.legend.Legend at 0x14e02ac89e48>
```



```
In [29]: #top 5 scores
         scores_df1.sort_values('Test_score',ascending=False).head(5)
```

```
Out[29]:    depth  Test_score  Test_std  Train_score
         5      9    0.872741  0.010143     0.916072
         4      8    0.872728  0.011507     0.907520
         3      7    0.872689  0.013214     0.900727
         6     11    0.869556  0.009616     0.936217
         2      5    0.866557  0.015469     0.889496
```

From 10 fold cv we can observe that good depth is 9 with cv score of 0.872741.

```
In [30]: #testscore
         #transforming to tfidf weighted word2vec
         tfidfvect_w2v = TfidfWeightedWord2Vec(w2v_model_300)
         tfidfvect_w2v.fit(train_df[['final_text','HelpfulnessNumerator',
                                     'HelpfulnessDenominator']].values)
         X_train_tfw2v = tfidfvect_w2v.transform(train_df[['final_text',
                         'HelpfulnessNumerator','HelpfulnessDenominator']].values)
         X_cv_tfw2v = tfidfvect_w2v.transform(test_df[['final_text',
                          'HelpfulnessNumerator','HelpfulnessDenominator']].values)
```

```
model = DT(max_depth=9)
model.fit(X_train_tfw2v,train_df.Score)
#Predicting training data
train_list = model.predict(X_train_tfw2v)
#Accuracy score
score_train = accuracy_score(train_df.Score,train_list)
#predict test cv
test_list = model.predict(X_cv_tfw2v)
#Accuracy score
score_test = accuracy_score(test_df.Score,test_list)
#precision
#precision
test_precision = precision_score(test_df.Score,test_list)
#recall
test_recall = recall_score(test_df.Score,test_list)
#confusion matrix
confusion_matrix_test = confusion_matrix(test_df.Score,test_list)
print('Depth',9)
print('Train Score', score_train)
print('Test Score',score_test)
print('Test Precision',test_precision)
print('Test Recall',test_recall)
print('Test ConfusionMatrix',confusion_matrix_test)
```

```
Depth 9
Train Score 0.8931586380040797
Test Score 0.8538869209435154
Test Precision 0.8665547048653989
Test Recall 0.9727742536485827
Test ConfusionMatrix [[ 5571 13508]
 [ 2455 87717]]
```

Bag of Words:

```
In [31]: #BoW with cleaned data and without stopwords
         #simple cv for train data
         scores_train = []
         from nltk.corpus import stopwords
         stop = set(stopwords.words('english'))
         stop.remove('not')
         stop.remove('very')
         #CountVectorizer for BoW
         count_vect = CountVectorizer(stop_words=list(stop),dtype=np.int8)
         X_train = train_df.iloc[:round(train_df.shape[0]*0.70),:]
         X_test_cv = train_df.iloc[round(train_df.shape[0]*0.70):,:]
         final_counts_train = count_vect.fit_transform(
                 X_train['final_text'].values)
```

```
        #test
        X_test = count_vect.transform(X_test_cv['final_text'].values)
```

```
In [33]: for i in [1,3,5,7,9,11,13,15,17,19]:
             model = DT(max_depth=i).fit(final_counts_train,X_train.Score)
             #train score
             train_score = model.score(final_counts_train,X_train.Score)
             #test score
             test_score = model.score(X_test,X_test_cv.Score)
             print('Depth',i,'Train Score',train_score,'Test Score',test_score)
```

```
Depth 1 Train Score 0.8600121046378696 Test Score 0.8293451540352529
Depth 3 Train Score 0.8621752482571563 Test Score 0.8318034416025942
Depth 5 Train Score 0.8667256954562776 Test Score 0.8381322244887285
Depth 7 Train Score 0.8699760148842214 Test Score 0.8407735760238506
Depth 9 Train Score 0.8807076729954495 Test Score 0.8607275485119514
Depth 11 Train Score 0.8883571316491449 Test Score 0.8659840995867985
Depth 13 Train Score 0.8967070901795521 Test Score 0.8666902034625242
Depth 15 Train Score 0.9028714890946179 Test Score 0.8681154872116742
Depth 17 Train Score 0.9085035081033825 Test Score 0.8693838589884408
Depth 19 Train Score 0.9145838470332429 Test Score 0.8715152466133166
```

```
In [34]: for i in [23,25,27,35,40,45,50,70]:
             model = DT(max_depth=i).fit(final_counts_train,X_train.Score)
             #train score
             train_score = model.score(final_counts_train,X_train.Score)
             #test score
             test_score = model.score(X_test,X_test_cv.Score)
             print('Depth',i,'Train Score',train_score,'Test Score',test_score)
```

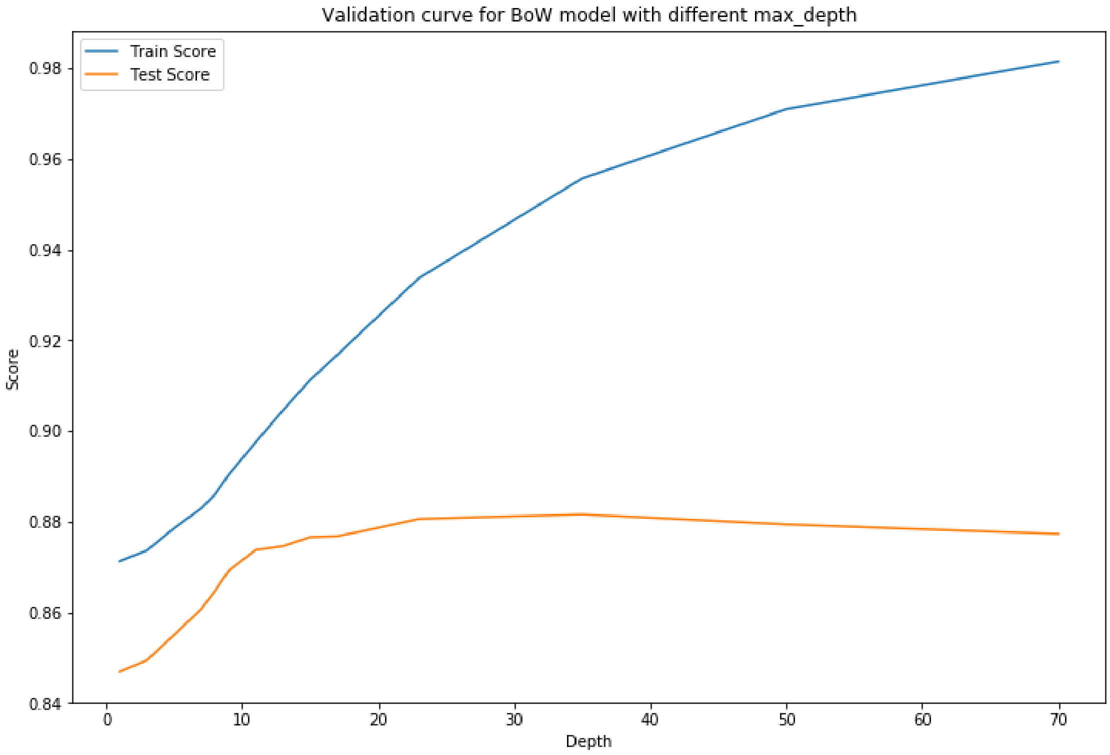
```
Depth 23 Train Score 0.9259935890251283 Test Score 0.876549505727287
Depth 25 Train Score 0.9308802761650714 Test Score 0.8764710497410952
Depth 27 Train Score 0.934982403443097 Test Score 0.8760656938124379
Depth 35 Train Score 0.9501524287731725 Test Score 0.8769548616559444
Depth 40 Train Score 0.9572863195176078 Test Score 0.8767456456927664
Depth 45 Train Score 0.9623075026338795 Test Score 0.8764187457503008
Depth 50 Train Score 0.9668187218399049 Test Score 0.8754772739159998
Depth 70 Train Score 0.9780827598574343 Test Score 0.8750980699827396
```

```
In [53]: #grid search
         param_grid = {'decisiontreeclassifier__max_depth':[1,3,5,
                             7,8,9,11,13,15,17,19,23,35,50,70]}
         model_grid_bow = GridSearchCV(make_pipeline(
                     CountVectorizer(stop_words=list(stop),dtype=np.int8),
                                                      DT()),
                                              param_grid=param_grid,
                                         cv=TimeSeriesSplit(n_splits=10),
                                            n_jobs=-1)
        model_grid_bow .fit(train_df.final_text.values,train_df.Score)
```

```
In [55]: dict_scores = []
         idx = 0
         for i in model_grid_bow.grid_scores_:
             dict_score = []
             dict_score.append(i[0]['decisiontreeclassifier__max_depth'])
             dict_score.append(i[1])
             dict_score.append(i[2].std())
             dict_score.append(model_grid_bow.cv_results_['mean_train_score'][idx])
             dict_scores.append(dict_score)
             idx = idx + 1
         scores_df = pd.DataFrame(dict_scores,columns=['depth','Test_score',
                                                       'Test_std','Train_score'])
```

```
In [56]: plt.figure(figsize=(12,8))
         plt.plot(scores_df.depth,scores_df.Train_score,label='Train Score')
         plt.plot(scores_df.depth,scores_df.Test_score,label='Test Score')
         plt.title('Validation curve for BoW model with different max_depth')
         plt.xlabel('Depth')
         plt.ylabel('Score')
         plt.legend()
```

```
Out[56]: <matplotlib.legend.Legend at 0x14df4881ccc0>
```



```
In [57]: scores_df.sort_values('Test_score',ascending=False)
```

```
Out[57]:     depth  Test_score  Test_std  Train_score
         12     35    0.881535  0.007312     0.955675
         11     23    0.880539  0.007810     0.933671
         13     50    0.879348  0.007243     0.970945
         10     19    0.877954  0.009595     0.922455
         14     70    0.877250  0.007491     0.981497
         9      17    0.876733  0.010275     0.916729
         8      15    0.876517  0.010974     0.911208
         7      13    0.874536  0.011799     0.904508
         6      11    0.873721  0.010701     0.897472
         5       9    0.869086  0.012684     0.890258
         4       8    0.864641  0.015348     0.885937
         3       7    0.860680  0.017437     0.882900
         2       5    0.854971  0.019846     0.878509
         1       3    0.849357  0.020504     0.873588
         0       1    0.846880  0.020501     0.871226
```

Depth with 23 to 35 might be better option for bag of words representation of data. for better time complexity and for low variance , maximum depth taken as 23 with mean cv of 0.880539

```
In [9]: #Test scores
        from nltk.corpus import stopwords
        stop = set(stopwords.words('english'))
        stop.remove('not')
        stop.remove('very')
        #CountVectorizer for BoW
        count_vect = CountVectorizer(stop_words=list(stop),dtype=np.int8)
        final_counts_train = count_vect.fit_transform(
                train_df['final_text'].values)
        #test
        X_test = count_vect.transform(test_df['final_text'].values)

        model = DT(max_depth=23)
        model.fit(final_counts_train,train_df.Score)
        #Predicting training data
        train_list = model.predict(final_counts_train)
        #Accuracy score
        score_train = accuracy_score(train_df.Score,train_list)
        #predict test cv
        test_list = model.predict(X_test)
        #Accuracy score
        score_test = accuracy_score(test_df.Score,test_list)
        #precision
        #precision
        test_precision = precision_score(test_df.Score,test_list)
        #recall
        test_recall = recall_score(test_df.Score,test_list)
        #confusion matrix
        confusion_matrix_test = confusion_matrix(test_df.Score,test_list)
        print('Depth',23)
        print('Train Score', score_train)
        print('Test Score',score_test)
        print('Test Precision',test_precision)
        print('Test Recall',test_recall)
        print('Test ConfusionMatrix',confusion_matrix_test)
```

```
Depth 23
Train Score 0.9213243370469166
Test Score 0.8763672643728662
Test Precision 0.9049877972763098
Test Recall 0.9499401144479439
Test ConfusionMatrix [[10086  8993]
 [ 4514 85658]]
```

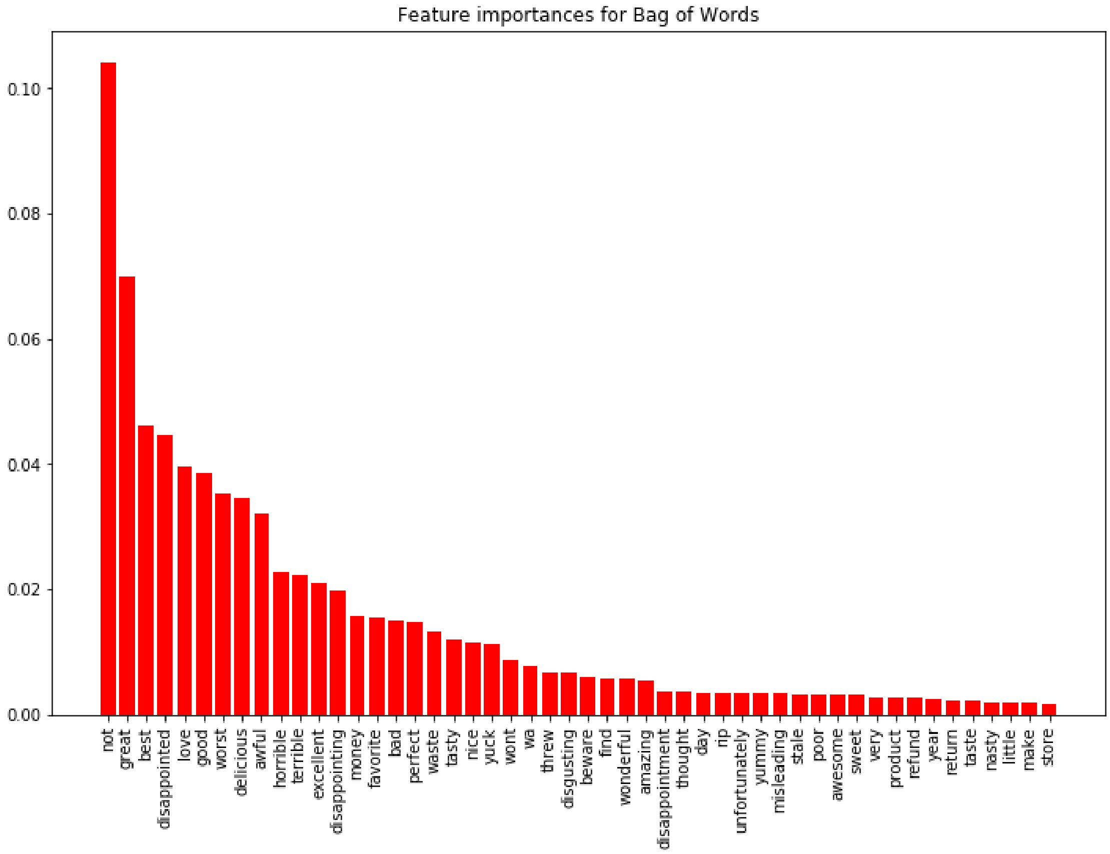
```
In [10]: import operator
         importances = model.feature_importances_
         features = count_vect.get_feature_names()
         dict_feature = dict(zip(features,importances))
         sorted_feature = dict(sorted(dict_feature.items(), key=operator.itemgetter(1),reverse=
```

```
In [11]: #To 100 features to seperate the data using Bag of words with RF
         list_feature = list(sorted_feature.keys())[0:100]
         list_fval = list(sorted_feature.values())[0:100]
         print(list_feature)
```

```
['not', 'great', 'best', 'disappointed', 'love', 'good', 'worst', 'delicious', 'awful', 'horril
```

```
In [12]: plt.figure(figsize=(12,8))
         plt.title("Feature importances for Bag of Words")
         plt.bar(range(len(list_feature[0:50])),list_fval[0:50],
                color="r")
         plt.xticks(range(len(list_feature[0:50])),
                    list_feature[0:50],rotation = 90)
```

```
Out[12]: ([<matplotlib.axis.XTick at 0x154442851a20>,
           <matplotlib.axis.XTick at 0x154441e06470>,
           <matplotlib.axis.XTick at 0x154441dfb470>,
           <matplotlib.axis.XTick at 0x1544593d9e48>,
           <matplotlib.axis.XTick at 0x1544599e74e0>,
           <matplotlib.axis.XTick at 0x1544599e7b38>,
           <matplotlib.axis.XTick at 0x1544599b5208>,
           <matplotlib.axis.XTick at 0x1544599b5898>,
           <matplotlib.axis.XTick at 0x1544599b5f28>,
           <matplotlib.axis.XTick at 0x154458e815f8>,
           <matplotlib.axis.XTick at 0x154458e81c88>,
           <matplotlib.axis.XTick at 0x154459a2e358>,
           <matplotlib.axis.XTick at 0x154459a2e9e8>,
           <matplotlib.axis.XTick at 0x154459a160b8>,
           <matplotlib.axis.XTick at 0x154459a16748>,
           <matplotlib.axis.XTick at 0x154459a16dd8>,
           <matplotlib.axis.XTick at 0x1544594c44a8>,
           <matplotlib.axis.XTick at 0x1544594c4b38>,
           <matplotlib.axis.XTick at 0x154458fd0208>,
           <matplotlib.axis.XTick at 0x154458fd0898>,
           <matplotlib.axis.XTick at 0x154458fd0f28>,
           <matplotlib.axis.XTick at 0x154458fe75f8>,
           <matplotlib.axis.XTick at 0x154458fe7c88>,
           <matplotlib.axis.XTick at 0x154459ac9358>,
           <matplotlib.axis.XTick at 0x154459ac99e8>,
           <matplotlib.axis.XTick at 0x154459ac70b8>,
           <matplotlib.axis.XTick at 0x154459ac7748>,
           <matplotlib.axis.XTick at 0x154459ac7dd8>,
           <matplotlib.axis.XTick at 0x154458d0e4a8>,
           <matplotlib.axis.XTick at 0x154458d0eb38>,
           <matplotlib.axis.XTick at 0x154458bb9208>,
           <matplotlib.axis.XTick at 0x154458bb9898>,
           <matplotlib.axis.XTick at 0x154458bb9f28>,
           <matplotlib.axis.XTick at 0x154458be35f8>,
           <matplotlib.axis.XTick at 0x154458be3c88>,
           <matplotlib.axis.XTick at 0x1544589cb358>,
           <matplotlib.axis.XTick at 0x1544589cb9e8>,
           <matplotlib.axis.XTick at 0x15445880f0b8>,
           <matplotlib.axis.XTick at 0x15445880f748>,
           <matplotlib.axis.XTick at 0x15445880fdd8>,
           <matplotlib.axis.XTick at 0x1544588214a8>,
           <matplotlib.axis.XTick at 0x154441e123c8>,
           <matplotlib.axis.XTick at 0x1544588219e8>,
           <matplotlib.axis.XTick at 0x1544585c20b8>,
           <matplotlib.axis.XTick at 0x1544585c2748>,
           <matplotlib.axis.XTick at 0x1544585c2dd8>,
           <matplotlib.axis.XTick at 0x1544584784a8>,
           <matplotlib.axis.XTick at 0x154458478b38>,
           <matplotlib.axis.XTick at 0x15445849c208>,
           <matplotlib.axis.XTick at 0x15445849c898>],
          <a list of 50 Text xticklabel objects>)
```



Tf-Idf

In [60]:
```
#TFIDF with (1,2) gram with cleaned data
#simple cv for train data
#tfidf vec
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2))
X_train = train_df.iloc[:round(train_df.shape[0]*0.70),:]
X_test_cv = train_df.iloc[round(train_df.shape[0]*0.70):,:]
final_counts_train = tf_idf_vect.fit_transform(
        X_train['final_text'].values)
#test
X_test = tf_idf_vect.transform(X_test_cv['final_text'].values)
```

In [61]:
```
for i in [1,3,5,7,9,11,13,15,17,19]:
    model = DT(max_depth=i).fit(final_counts_train,X_train.Score)
    #train score
    train_score = model.score(final_counts_train,X_train.Score)
    #test score
    test_score = model.score(X_test,X_test_cv.Score)
    print('Depth',i,'Train Score',train_score,'Test Score',test_score)
```

```
Depth 1 Train Score 0.8600121046378696 Test Score 0.8293451540352529
Depth 3 Train Score 0.8622481002443344 Test Score 0.8319342015795805
Depth 5 Train Score 0.868266795185044 Test Score 0.8390998483184267
Depth 7 Train Score 0.8752717939521643 Test Score 0.8560201893404467
Depth 9 Train Score 0.8867431799332003 Test Score 0.8646241958261416
Depth 11 Train Score 0.8949250184931967 Test Score 0.8700245828756734
Depth 13 Train Score 0.9030508170630562 Test Score 0.8715283226110152
Depth 15 Train Score 0.9088677680392728 Test Score 0.8721036665097547
Depth 17 Train Score 0.9153459908991056 Test Score 0.8743658141116167
Depth 19 Train Score 0.9211965658694045 Test Score 0.8762487577802186
```

```
In [12]: for i in [23,25,27,35,40,45]:
             model = DT(max_depth=i).fit(final_counts_train,X_train.Score)
             #train score
             train_score = model.score(final_counts_train,X_train.Score)
             #test score
             test_score = model.score(X_test,X_test_cv.Score)
             print('Depth',i,'Train Score',train_score,'Test Score',test_score)
```

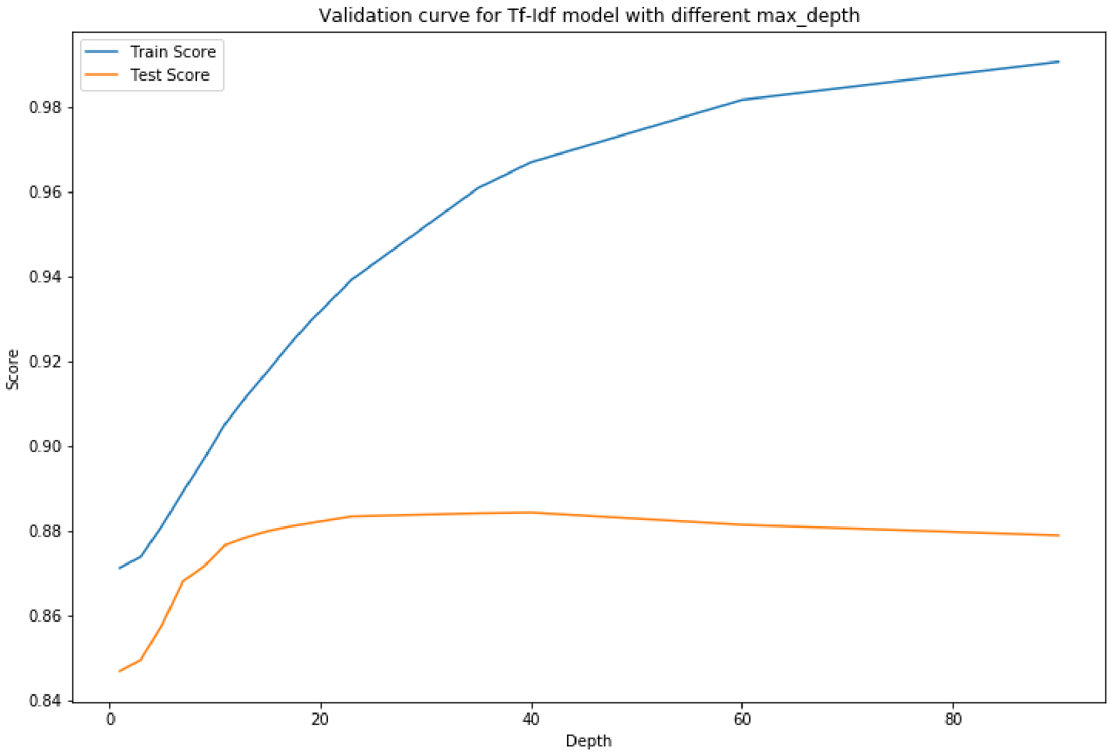
```
Depth 23 Train Score 0.9326735558494542 Test Score 0.8789816412992312
Depth 25 Train Score 0.9371511510613975 Test Score 0.8800538731105183
Depth 27 Train Score 0.9402669745130124 Test Score 0.8804069250483811
Depth 35 Train Score 0.9523716123825963 Test Score 0.8829175166065171
Depth 40 Train Score 0.959421443141826 Test Score 0.8833228725351744
Depth 45 Train Score 0.9646275582255498 Test Score 0.8819368167791203
```

```
In [42]: param_grid = {'decisiontreeclassifier__max_depth':
                           [1,3,5,7,9,11,13,15,17,19,23,35,40,60,90]}
         model_grid_tfidf = GridSearchCV(make_pipeline(
                             TfidfVectorizer(ngram_range=(1,2)),DT()),
                                             param_grid=param_grid,
                                         cv=TimeSeriesSplit(n_splits=10),
                                                           n_jobs=-1)
         model_grid_tfidf.fit(train_df.final_text.values,train_df.Score)
```

```
In [43]: dict_scores = []
         idx = 0
         for i in model_grid_tfidf.grid_scores_:
             dict_score = []
             dict_score.append(i[0]['decisiontreeclassifier__max_depth'])
             dict_score.append(i[1])
             dict_score.append(i[2].std())
             dict_score.append(model_grid_tfidf.cv_results_['mean_train_score'][idx])
             dict_scores.append(dict_score)
             idx = idx + 1
         scores_df = pd.DataFrame(dict_scores,columns=['depth','Test_score',
                                                       'Test_std','Train_score'])
```

In [44]:
```
plt.figure(figsize=(12,8))
plt.plot(scores_df.depth,scores_df.Train_score,label='Train Score')
plt.plot(scores_df.depth,scores_df.Test_score,label='Test Score')
plt.title('Validation curve for Tf-Idf model with different max_depth')
plt.xlabel('Depth')
plt.ylabel('Score')
plt.legend()
```

Out[44]:
```
<matplotlib.legend.Legend at 0x149213874710>
```



In [46]:
```
scores_df.sort_values('Test_score',ascending=False).head(10)
```

Out[46]:
```
    depth  Test_score  Test_std  Train_score
12     40    0.884301  0.005215     0.966856
11     35    0.884120  0.005923     0.960791
10     23    0.883378  0.008458     0.939165
9      19    0.881751  0.009670     0.929148
13     60    0.881384  0.005097     0.981552
8      17    0.880918  0.010221     0.923587
7      15    0.879883  0.010582     0.917458
14     90    0.878903  0.005205     0.990540
6      13    0.878424  0.011582     0.911619
5      11    0.876616  0.012583     0.905149
```

Better scores is greater than 23 and 23 is good to choose with mean cv of 0.883378

```
In [13]: #test scores
         #TFIDF with (1,2) gram with cleaned data
         #tfidf vec
         tf_idf_vect = TfidfVectorizer(ngram_range=(1,2))
         final_counts_train = tf_idf_vect.fit_transform(
                 train_df['final_text'].values)
         #test
         X_test = tf_idf_vect.transform(test_df['final_text'].values)

         model = DT(max_depth=23,random_state=25)
         model.fit(final_counts_train,train_df.Score)
         #Predicting training data
         train_list = model.predict(final_counts_train)
         #Accuracy score
         score_train = accuracy_score(train_df.Score,train_list)
         #predict test cv
         test_list = model.predict(X_test)
         #Accuracy score
         score_test = accuracy_score(test_df.Score,test_list)
         #precision
         #precision
         test_precision = precision_score(test_df.Score,test_list)
         #recall
         test_recall = recall_score(test_df.Score,test_list)
         #confusion matrix
         confusion_matrix_test = confusion_matrix(test_df.Score,test_list)
         print('depth',23)
         print('Train Score', score_train)
         print('Test Score',score_test)
         print('Test Precision',test_precision)
         print('Test Recall',test_recall)
         print('Test ConfusionMatrix',confusion_matrix_test)
```

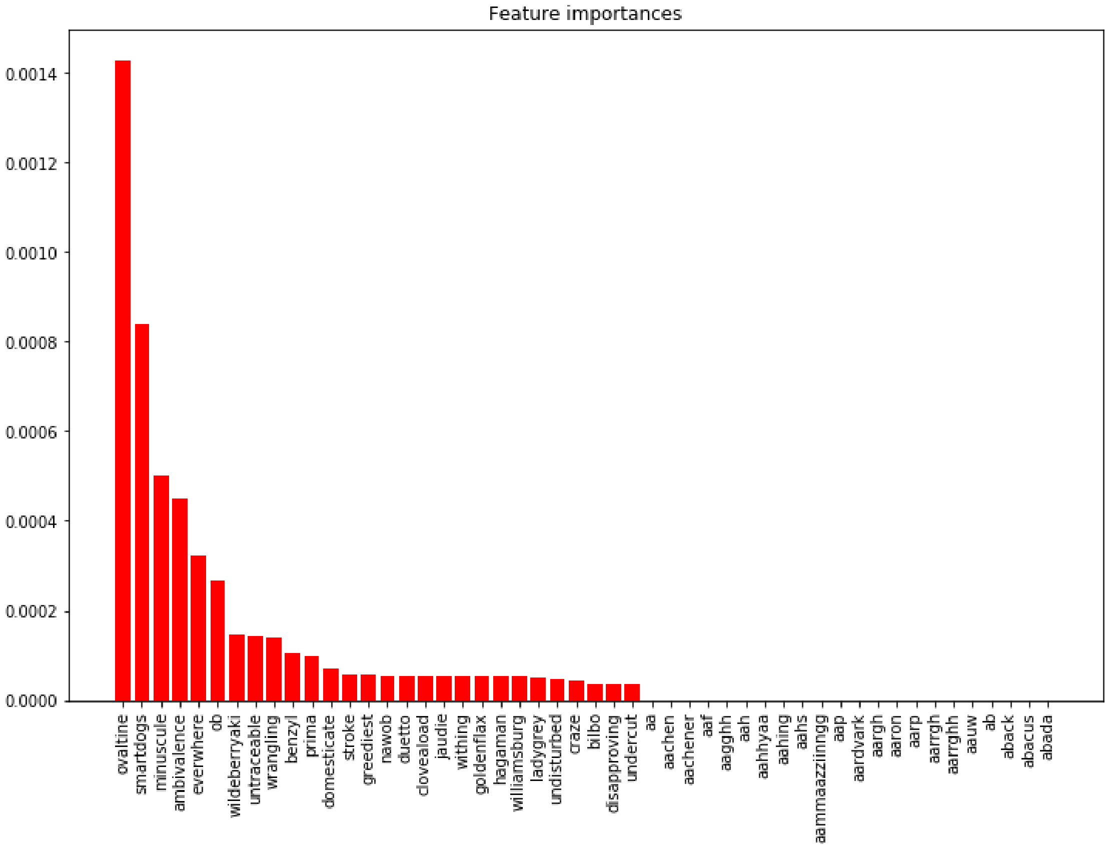
```
depth 23
Train Score 0.926549505727287
Test Score 0.8802482357140896
Test Precision 0.9094772179197076
Test Recall 0.9494077984296677
Test ConfusionMatrix [[10558  8521]
 [ 4562 85610]]
```

```
In [14]: import operator
         importances = model.feature_importances_
         features = count_vect.get_feature_names()
         dict_feature = dict(zip(features,importances))
         sorted_feature = dict(sorted(dict_feature.items(), key=operator.itemgetter(1),reverse=
In [15]: #To 100 features to seperate the data using Bag of words with RF
         list_feature = list(sorted_feature.keys())[0:100]
         list_fval = list(sorted_feature.values())[0:100]
         print(list_feature)

['ovaltine', 'smartdogs', 'minuscule', 'ambivalence', 'everwhere', 'ob', 'wildeberryaki', 'unt
```

```
In [16]: plt.figure(figsize=(12,8))
         plt.title("Feature importances")
         plt.bar(range(len(list_feature[0:50])),list_fval[0:50],
                color="r")
         plt.xticks(range(len(list_feature[0:50])),
                    list_feature[0:50],rotation = 90)

Out[16]: ([<matplotlib.axis.XTick at 0x1543f38bef98>,
           <matplotlib.axis.XTick at 0x1543f3b206a0>,
           <matplotlib.axis.XTick at 0x1543f3897940>,
           <matplotlib.axis.XTick at 0x15443f1552b0>,
           <matplotlib.axis.XTick at 0x15443f155940>,
           <matplotlib.axis.XTick at 0x15443f155fd0>,
           <matplotlib.axis.XTick at 0x15444a1cb6a0>,
           <matplotlib.axis.XTick at 0x15444a1cbd30>,
           <matplotlib.axis.XTick at 0x1543f25ca400>,
           <matplotlib.axis.XTick at 0x1543f25caa90>,
           <matplotlib.axis.XTick at 0x1543f2c34160>,
           <matplotlib.axis.XTick at 0x1543f2c347f0>,
           <matplotlib.axis.XTick at 0x1543f2c34e80>,
           <matplotlib.axis.XTick at 0x154441ac4550>,
           <matplotlib.axis.XTick at 0x154441ac4be0>,
           <matplotlib.axis.XTick at 0x15443e8ec2b0>,
           <matplotlib.axis.XTick at 0x15443e8ec940>,
           <matplotlib.axis.XTick at 0x15443e8ecfd0>,
           <matplotlib.axis.XTick at 0x1543ecf286a0>,
           <matplotlib.axis.XTick at 0x1543ecf28d30>,
           <matplotlib.axis.XTick at 0x15443b948400>,
           <matplotlib.axis.XTick at 0x15443b948a90>,
           <matplotlib.axis.XTick at 0x154440b96160>,
           <matplotlib.axis.XTick at 0x154440b967f0>,
           <matplotlib.axis.XTick at 0x154440b96e80>,
           <matplotlib.axis.XTick at 0x1543f0051550>,
           <matplotlib.axis.XTick at 0x1543f0051be0>,
           <matplotlib.axis.XTick at 0x1543ef0da2b0>,
           <matplotlib.axis.XTick at 0x1543ef0da940>,
           <matplotlib.axis.XTick at 0x1543ef0dafd0>,
           <matplotlib.axis.XTick at 0x1543f059d6a0>,
           <matplotlib.axis.XTick at 0x1543f059dd30>,
           <matplotlib.axis.XTick at 0x1543f20fa400>,
           <matplotlib.axis.XTick at 0x1543f20faa90>,
           <matplotlib.axis.XTick at 0x154456f3a160>,
           <matplotlib.axis.XTick at 0x154456f3a7f0>,
           <matplotlib.axis.XTick at 0x154456f3ae80>,
           <matplotlib.axis.XTick at 0x15444cf3b550>,
           <matplotlib.axis.XTick at 0x15444cf3bbe0>,
           <matplotlib.axis.XTick at 0x1544469ab2b0>,
           <matplotlib.axis.XTick at 0x1544469ab940>,
           <matplotlib.axis.XTick at 0x1544469abfd0>,
           <matplotlib.axis.XTick at 0x1543ecefb6a0>,
           <matplotlib.axis.XTick at 0x1543ecefbd30>,
           <matplotlib.axis.XTick at 0x1543f0ed8400>,
           <matplotlib.axis.XTick at 0x1543f0ed8a90>,
           <matplotlib.axis.XTick at 0x1543f267a160>,
           <matplotlib.axis.XTick at 0x1543f267a7f0>,
           <matplotlib.axis.XTick at 0x1543f267ae80>,
           <matplotlib.axis.XTick at 0x154441a01550>],
          <a list of 50 Text xticklabel objects>)
```



Observations:

1. For Avg Word2Vec representation of data got best cv at depth = 8 and mean cv score is 0.879296.
    - Train Score 0.8931115644123646
    - Test Score 0.8619692268262991
    - Test Precision 0.8777263581488933
    - Test Recall 0.9675509027192477
    - Test ConfusionMatrix

$$\begin{bmatrix} 6925 & 12154 \\ 2926 & 87246 \end{bmatrix} \tag{1}$$

2. For Tf-Idf Word2Vec representation got best cv at depth = 9 with cv score of 0.872741.
    - Train Score 0.8931586380040797
    - Test Score 0.8538869209435154
    - Test Precision 0.8665547048653989
    - Test Recall 0.9727742536485827
    - Test ConfusionMatrix

$$\begin{bmatrix} 5571 & 13508 \\ 2455 & 87717 \end{bmatrix} \tag{2}$$

3. For Bag of Words representation , got best cv at depth = 23 with mean cv score of 0.880539.
    - Train Score 0.9211909618703907
    - Test Score 0.8762848852642081
    - Test Precision 0.9049873203719357
    - Test Recall 0.9498292152774698
    - Test ConfusionMatrix

$$\begin{bmatrix} 10087 & 8992 \\ 4524 & 85648 \end{bmatrix} \tag{3}$$

4. For Tf-Idf with bi-gram representation, got best cv at depth = 23 is with mean cv score of 0.883378.
    - Train Score 0.926549505727287
    - Test Score 0.8802482357140896
    - Test Precision 0.9094772179197076
    - Test Recall 0.9494077984296677
    - Test ConfusionMatrix

$$\begin{bmatrix} 10558 & 8521 \\ 4562 & 85610 \end{bmatrix} \tag{4}$$