Random Forest and XGBoost on Amazon Food Reviews

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

Objective: Given Amazon Food reviews, convert all the reviews into a vector using two techniques:
1. Average W2V.
2. Average TFIDF-W2V.

Then perform following tasks under each technique:
Task 1. Split train and test data in a ratio of 80:20.
Task 2. Perform GridSearch Cross Validation to find optimal value of number of base models in Random Forest.
Task 3. Apply Random Forest and report accuracy. Also check for train error.

Task 4. Perform GridSearch Cross Validation to find optimal number of base models and optimal value of depth of decision tree base models in XGBoost.
Task 5. Apply XGBoost and report accuracy. Also check for train error.

[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.

Loading the data

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 [3]:

```
import sqlite3
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt

from gensim.models import Word2Vec
import gensim
from sklearn.metrics import accuracy_score, confusion_matrix
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.ensemble import RandomForestClassifier
import xgboost as xgb
from sklearn.cross_validation import train_test_split
from sklearn.grid_search import GridSearchCV
```

In [4]:

```
connection = sqlite3.connect('FinalAmazonFoodReviewsDataset.sqlite')
```

In [5]:

```
data = pd.read_sql_query("SELECT * FROM Reviews", connection)
```

```
In [6]: data.head()
```

Out[6]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summary	
0	0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1	Positive	1303862400	Good Quality Dog Food	se
1	1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0	Negative	1346976000	Not as Advertised	lal
2	2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1	Positive	1219017600	"Delight" says it all	F . cc a
3	4	5	B006K2ZZ7K	A1UQRSCLF8GW1T	Michael D. Bigham "M. Wassir"	0	0	Positive	1350777600	Great taffy	t
4	5	6	B006K2ZZ7K	ADT0SRK1MGOEU	Twoapennything	0	0	Positive	1342051200	Nice Taffy	.

```
In [7]: data.shape
```

```
Out[7]: (364171, 12)
```

In [8]:
```
data["Score"].value_counts()
```

Out[8]:
```
Positive    307061
Negative     57110
Name: Score, dtype: int64
```

In [9]:
```
def changingScores(score):
    if score == "Positive":
        return 1
    else:
        return 0
```

In [10]:
```
# changing score
# Positive = 1
# Negative = 0
actualScore = list(data["Score"])
positiveNegative = list(map(changingScores, actualScore)) #map(function, list of numbers)
data['Score'] = positiveNegative
```

In [11]:
```
#taking 10000 random samples
data = data.sample(n = 10000)
```

In [12]:
```
data.head()
```

Out[12]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summa
1771	2319	2525	B000NY4SZQ	A1IDF30FSGME1L	Shari	2	2	1	1283040000	Thor Musta Mani
307570	442577	478546	B000E3XCG2	A3N8XPE3QXZ62Q	Connie L. Roberts "Daeshii"	1	1	1	1185321600	C Yumm
309959	445341	481519	B004OY7FD8	A18F3YI8GZCIIY	Karmali	0	0	1	1340496000	Delicio cracke
183392	259085	280861	B000FFLHSY	A3JETXRRUHIOUH	rain21004	3	4	0	1271980800	Dra clear
303846	436877	472419	B001F1U5WG	A1GZVRXW89KZST	kawtamer	1	1	1	1301011200	Gre

In [13]:
```
data.shape
```

Out[13]:
```
(10000, 12)
```

In [14]:
```
data["Score"].value_counts()
```

Out[14]:
```
1    8456
0    1544
Name: Score, dtype: int64
```

In [15]:
```
data = data.sort_values('Time', axis=0, ascending=True)
```

In [16]:
```
Data = data
```

In [17]:
```
Data_Labels = data["Score"]
```

In [18]:
```
print(Data.shape)
print(Data_Labels.shape)
```

```
(10000, 12)
(10000,)
```

In [19]:
```
Data.head()
```

Out[19]:

	index	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	HelpfulnessDenominator	Score	Time	Summa
97415	138001	149770	B00004S1C5	A1KXONFPU2XQ5K	Stephanie Manley	8	8	1	965779200	Very ea to u
238632	346030	374332	B00004CI84	AEPJYN0NAX9N4	Jody L. Schoth	0	0	1	1014163200	Excellen Hilario
308591	443674	479736	B00005U2FA	A1UUIV2251UKHJ	S. McMillian	2	2	1	1052179200	Vacu \
267514	388413	419994	B0000A0BS5	A238V1XTSK9NFE	Andrew Lynn	46	59	0	1064361600	N actually t use espres machin
129891	184396	200021	B0000D9N5Q	A176XYKMRF1U8Q	Lance Arthur	0	0	1	1067990400	A sm taste heav

1. Avg W2V

In [20]:

```
i = 0
listOfSentences = []
for sentence in Data["ProcessedText"].values:
    subSentence = []
    for word in sentence.split():
        subSentence.append(word)

    listOfSentences.append(subSentence)
```

In [21]:

```
print(Data['ProcessedText'].values[0])
print("\n")
print(listOfSentences[0:2])
print("\n")
print(type(listOfSentences))
```

```
this are much easier use than the wilson past color color are vibrant and not taint the frost like some color can these
are simpl use and not make mess onli complaint that did not find these year ago this must have you decor often


[['this', 'are', 'much', 'easier', 'use', 'than', 'the', 'wilson', 'past', 'color', 'color', 'are', 'vibrant', 'and',
'not', 'taint', 'the', 'frost', 'like', 'some', 'color', 'can', 'these', 'are', 'simpl', 'use', 'and', 'not', 'make',
'mess', 'onli', 'complaint', 'that', 'did', 'not', 'find', 'these', 'year', 'ago', 'this', 'must', 'have', 'you', 'deco
r', 'often'], ['just', 'hilari', 'favorit', 'part', 'the', 'dine', 'room', 'scene', 'with', 'all', 'the', 'sing', 'an
d', 'danc', 'classic', 'moment', 'not', 'miss', 'winona', 'rider', 'and', 'geena', 'davi', 'are', 'spectacular', 'thi
s', 'movi', 'and', 'michael', 'keaton', 'unbeliev', 'funni', 'couldnt', 'stop', 'laugh', 'great', 'famili', 'movi', 'wi
ll', 'keep', 'you', 'stitch']]


<class 'list'>
```

In [22]:

```
w2vModel = gensim.models.Word2Vec(listOfSentences, size=300, min_count=5, workers=4)
```

In [23]:
```
# compute average word2vec for each review.
sentenceAsW2V = []
for sentence in listOfSentences:
    sentenceVector = np.zeros(300)
    TotalWordsPerSentence = 0
    for word in sentence:
        try:
            vect = w2vModel.wv[word]
            sentenceVector += vect
            TotalWordsPerSentence += 1
        except:
            pass
    if TotalWordsPerSentence!= 0:
        sentenceVector /= TotalWordsPerSentence
        sentenceAsW2V.append(sentenceVector)

print(type(sentenceAsW2V))
print(len(sentenceAsW2V))
print(len(sentenceAsW2V[0]))
```

```
<class 'list'>
10000
300
```

Task 1. Split train and test data in a ratio of 80:20.

In [24]:
```
X_train_AvgW2V, X_test_AvgW2V, Y_train_labels_AvgW2V, Y_test_labels_AvgW2V = train_test_split(sentenceAsW2V, Data_Labels,
```

In [25]:
```
train_AvgW2V = np.array(X_train_AvgW2V)
test_AvgW2V = np.array(X_test_AvgW2V)
train_labels_AvgW2V = np.array(Y_train_labels_AvgW2V)
test_labels_AvgW2V = np.array(Y_test_labels_AvgW2V)
```

In [26]:
```
train_AvgW2V.shape, test_AvgW2V.shape, train_labels_AvgW2V.shape, test_labels_AvgW2V.shape
```

Out[26]:
```
((8000, 300), (2000, 300), (8000,), (2000,))
```

Task 2. Perform GridSearch Cross Validation to find optimal value of number of base models in Random Forest.

In [125]:

```
values = []
for i in range(1, 31, 2):
    values.append(i)

clf = RandomForestClassifier(n_jobs = -1)

hyper_parameters = {'n_estimators': values}
bestScore = GridSearchCV(clf, hyper_parameters, scoring = "accuracy", cv = 3)
bestScore.fit(train_AvgW2V, train_labels_AvgW2V)

print(bestScore.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=29, n_jobs=-1,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
```

In [126]:

```
best_parameter = bestScore.best_params_
bp = best_parameter["n_estimators"]
bp
```

Out[126]:

```
29
```

In [127]:

```
scoreData = bestScore.grid_scores_
scoreData
```

Out[127]:

```
[mean: 0.78112, std: 0.00458, params: {'n_estimators': 1},
 mean: 0.83050, std: 0.00185, params: {'n_estimators': 3},
 mean: 0.83850, std: 0.00621, params: {'n_estimators': 5},
 mean: 0.85062, std: 0.00498, params: {'n_estimators': 7},
 mean: 0.85262, std: 0.00159, params: {'n_estimators': 9},
 mean: 0.85175, std: 0.00097, params: {'n_estimators': 11},
 mean: 0.85850, std: 0.00356, params: {'n_estimators': 13},
 mean: 0.86038, std: 0.00272, params: {'n_estimators': 15},
 mean: 0.85788, std: 0.00082, params: {'n_estimators': 17},
 mean: 0.85913, std: 0.00034, params: {'n_estimators': 19},
 mean: 0.85975, std: 0.00293, params: {'n_estimators': 21},
 mean: 0.85850, std: 0.00204, params: {'n_estimators': 23},
 mean: 0.86075, std: 0.00428, params: {'n_estimators': 25},
 mean: 0.86162, std: 0.00359, params: {'n_estimators': 27},
 mean: 0.86400, std: 0.00015, params: {'n_estimators': 29}]
```

In [128]:

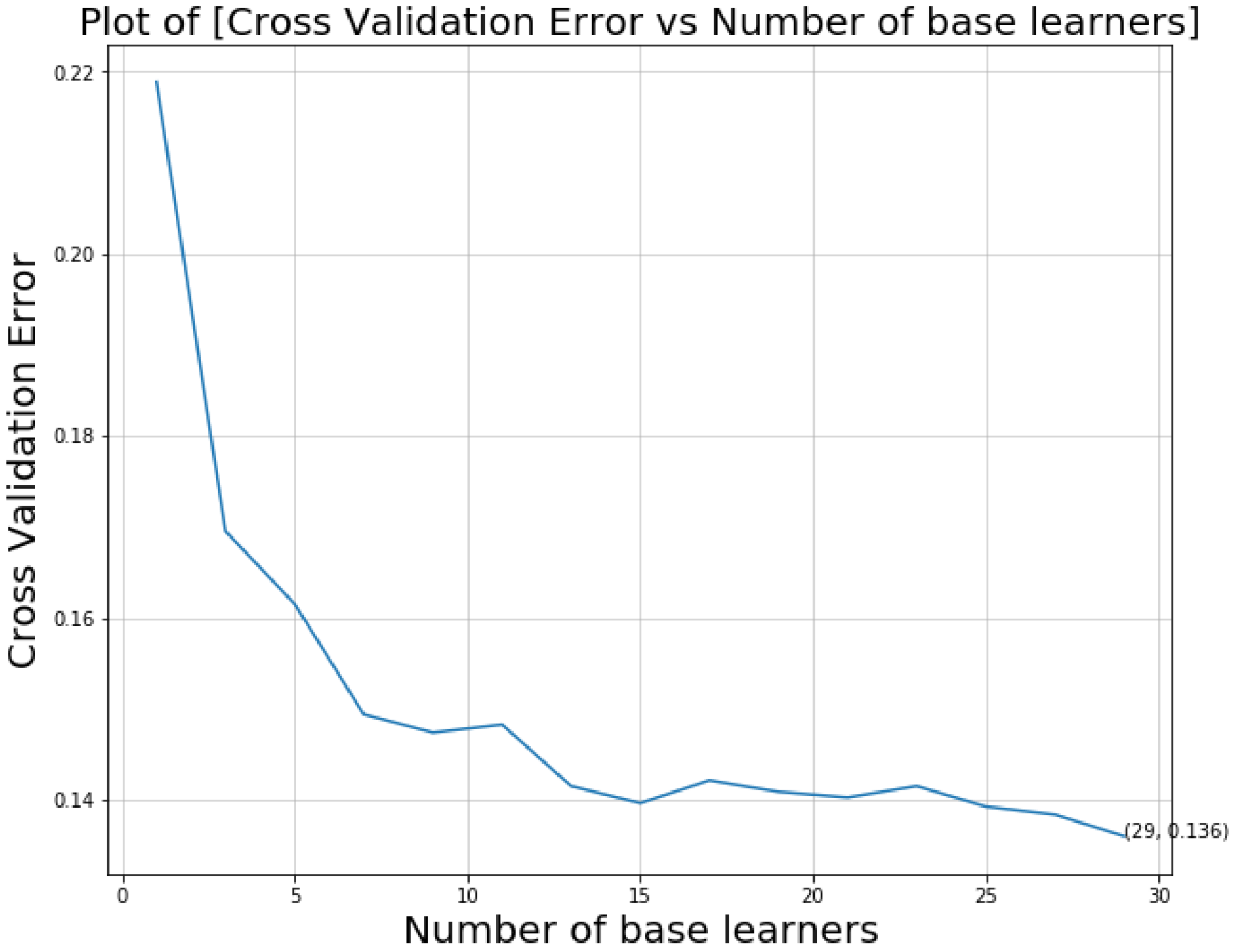
```
error = []
parameter = []
for i in range(len(scoreData)):
    error.append(1 - scoreData[i][1])
    parameter.append(scoreData[i][0]["n_estimators"])

plt.figure(figsize=(10,8))
plt.plot(parameter, error)

plt.title("Plot of [Cross Validation Error vs Number of base learners]", fontsize=20)
plt.xlabel("Number of base learners", fontsize=20)
plt.ylabel("Cross Validation Error", fontsize=20)
plt.grid(linestyle='-', linewidth=0.5)

errorMin = min(error)
errorMin

for xy in zip(parameter, error):
    if xy == (bp, errorMin):
        plt.annotate(xy, xy)
```



Task 3. Apply Random Forest and report accuracy. Also check for train error.

In [129]:

```
#First checking for train error
model_rf_tr = RandomForestClassifier(n_estimators = bp, n_jobs = -1)

model_rf_tr.fit(train_AvgW2V, train_labels_AvgW2V)

prediction_AvgW2V_rf_tr = model_rf_tr.predict(train_AvgW2V)

AccuracyScore_AvgW2V_rf_tr = accuracy_score(train_labels_AvgW2V, prediction_AvgW2V_rf_tr)

print("Train error of Random Forest = "+str(np.round(((1 - AccuracyScore_AvgW2V_rf_tr) * 100), 4))+"%")
```

```
Train error of Random Forest = 0.1%
```

In [130]:

```
model_rf = RandomForestClassifier(n_estimators = bp, n_jobs = -1)

model_rf.fit(train_AvgW2V, train_labels_AvgW2V)

prediction_AvgW2V_rf = model_rf.predict(test_AvgW2V)

AccuracyScore_AvgW2V_rf = accuracy_score(test_labels_AvgW2V, prediction_AvgW2V_rf) * 100

print("Accuracy score of Random Forest = "+str(AccuracyScore_AvgW2V_rf)+"%")
```

```
Accuracy score of Random Forest = 85.25%
```

In [131]:

```
Confusion_Matrix = confusion_matrix(test_labels_AvgW2V, prediction_AvgW2V_rf)
print("Confusion Matrix on L2 regularization  \n"+str(Confusion_Matrix))
```

```
Confusion Matrix on L2 regularization
[[  82  262]
 [  33 1623]]
```

In [132]:

```
tn, fp, fn, tp = confusion_matrix(test_labels_AvgW2V, prediction_AvgW2V_rf).ravel()
tn, fp, fn, tp
```

Out[132]:

```
(82, 262, 33, 1623)
```

Task 4. Perform GridSearch Cross Validation to find optimal number of base models and optimal value of depth of decision tree base models in XGBoost.

In [31]:

```
xgb_model = xgb.XGBClassifier()

hyperParameters = {'max_depth':[1, 2, 3, 4], 'n_estimators':[30, 50, 70, 100]}

clf = GridSearchCV(estimator = xgb_model, param_grid = hyperParameters, scoring='accuracy', cv=3)
clf.fit(train_AvgW2V, train_labels_AvgW2V)

print(clf.best_estimator_)
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
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```

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C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
```

```
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an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
that an array is not empty.
  if diff:
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
       max_depth=4, min_child_weight=1, missing=None, n_estimators=100,
       n_jobs=1, nthread=None, objective='binary:logistic', random_state=0,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=True, subsample=1)
```

In [32]:
```
best_parameter = clf.best_params_
best_parameter
```

Out[32]:
```
{'max_depth': 4, 'n_estimators': 100}
```

In [33]:
```
scoreData = clf.grid_scores_
scoreData
```

Out[33]:
```
[mean: 0.84350, std: 0.00012, params: {'max_depth': 1, 'n_estimators': 30},
 mean: 0.84613, std: 0.00072, params: {'max_depth': 1, 'n_estimators': 50},
 mean: 0.85037, std: 0.00078, params: {'max_depth': 1, 'n_estimators': 70},
 mean: 0.85525, std: 0.00086, params: {'max_depth': 1, 'n_estimators': 100},
 mean: 0.85200, std: 0.00186, params: {'max_depth': 2, 'n_estimators': 30},
 mean: 0.85650, std: 0.00204, params: {'max_depth': 2, 'n_estimators': 50},
 mean: 0.85800, std: 0.00450, params: {'max_depth': 2, 'n_estimators': 70},
 mean: 0.85825, std: 0.00455, params: {'max_depth': 2, 'n_estimators': 100},
 mean: 0.85588, std: 0.00390, params: {'max_depth': 3, 'n_estimators': 30},
 mean: 0.86087, std: 0.00615, params: {'max_depth': 3, 'n_estimators': 50},
 mean: 0.86038, std: 0.00522, params: {'max_depth': 3, 'n_estimators': 70},
 mean: 0.86075, std: 0.00586, params: {'max_depth': 3, 'n_estimators': 100},
 mean: 0.85975, std: 0.00527, params: {'max_depth': 4, 'n_estimators': 30},
 mean: 0.86087, std: 0.00606, params: {'max_depth': 4, 'n_estimators': 50},
 mean: 0.86287, std: 0.00540, params: {'max_depth': 4, 'n_estimators': 70},
 mean: 0.86513, std: 0.00589, params: {'max_depth': 4, 'n_estimators': 100}]
```

In [34]:
```
error = []
eachError = []
for i in range(len(scoreData)):
    eachError.append(np.round((1 - scoreData[i][1]), 4))
    if i == 3 or i == 7 or i == 11 or i == 15:
        error.append(eachError)
        eachError = []
```

In [35]:
```
error
```

Out[35]:
```
[[0.1565, 0.1539, 0.1496, 0.1448],
 [0.148, 0.1435, 0.142, 0.1418],
 [0.1441, 0.1391, 0.1396, 0.1392],
 [0.1402, 0.1391, 0.1371, 0.1349]]
```

In [36]:
```
columnNames = [30, 50, 70, 100]
```

In [37]:
```
errorFrame = pd.DataFrame(error, columns = columnNames)
```

In [38]:
```
errorFrame
```

Out[38]:

	30	50	70	100
0	0.1565	0.1539	0.1496	0.1448
1	0.1480	0.1435	0.1420	0.1418
2	0.1441	0.1391	0.1396	0.1392
3	0.1402	0.1391	0.1371	0.1349

In [39]:
```
indexNames = [1, 2, 3, 4]
errorFrame["Max_depth"] = indexNames
```

In [40]:
```
errorFrame
```

Out[40]:

	30	50	70	100	Max_depth
0	0.1565	0.1539	0.1496	0.1448	1
1	0.1480	0.1435	0.1420	0.1418	2
2	0.1441	0.1391	0.1396	0.1392	3
3	0.1402	0.1391	0.1371	0.1349	4

In [41]:
```
errorFrame.set_index("Max_depth", append = False, drop = True, inplace = True)
```

In [42]:

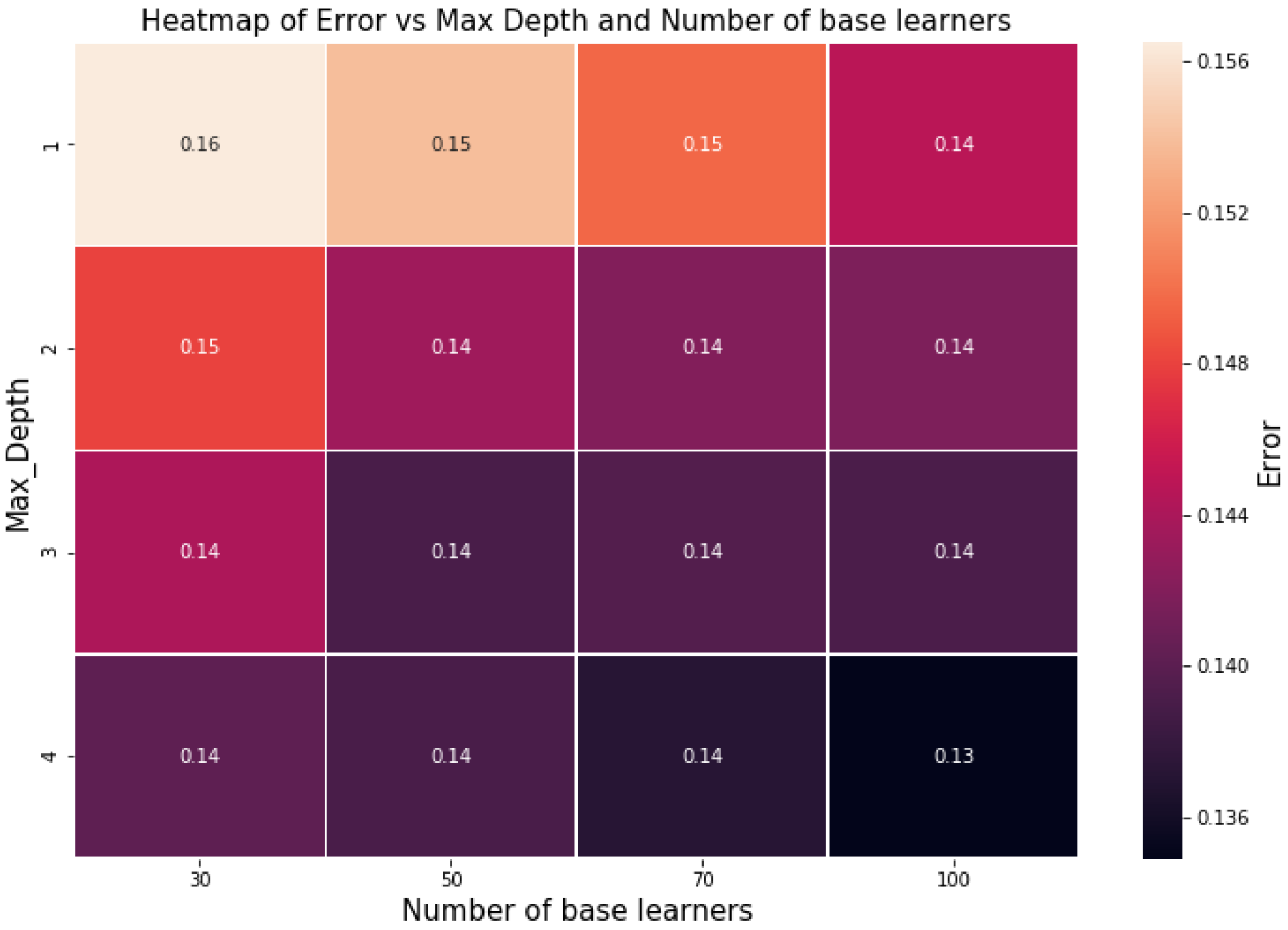
```
errorFrame
```

Out[42]:

	30	50	70	100
Max_depth				
1	0.1565	0.1539	0.1496	0.1448
2	0.1480	0.1435	0.1420	0.1418
3	0.1441	0.1391	0.1396	0.1392
4	0.1402	0.1391	0.1371	0.1349

```
In [43]: plt.figure(figsize=(12, 8))
         plt.title("Heatmap of Error vs Max Depth and Number of base learners", size = 15)
         ax = sns.heatmap(errorFrame, annot = True, linewidths=.5)
         ax.figure.axes[0].set_xlabel('Number of base learners', size = 15)
         ax.figure.axes[0].set_ylabel('Max_Depth', size = 15)
         ax.figure.axes[-1].set_ylabel('Error', size = 15)
```

```
Out[43]: Text(738.529,0.5,'Error')
```



Here above in heatmap you can see that the error is minimum when Number of base learners are 100 and Max_Depth value is 4. Therefore,

from grid search we are considering our Number of base learners value as 100 and Max_Depth Value as 4.

Task 5. Apply XGBoost and report accuracy. Also check for train error.

In [45]:

```
#checking for train error
model_xg_tr = xgb.XGBClassifier(max_depth = 4, n_estimators = 100)

model_xg_tr.fit(train_AvgW2V, train_labels_AvgW2V)

prediction_AvgW2V_xg_tr = model_xg_tr.predict(train_AvgW2V)

AccuracyScore_AvgW2V_xg_tr = accuracy_score(train_labels_AvgW2V, prediction_AvgW2V_xg_tr)

print("Train Error of XGBoost = "+str((1 - AccuracyScore_AvgW2V_xg_tr) * 100)+"%")
```

```
Train Error of XGBoost = 8.1125%

C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
that an array is not empty.
  if diff:
```

In [49]:

```
model_xg = xgb.XGBClassifier(max_depth = 4, n_estimators = 100)

model_xg.fit(train_AvgW2V, train_labels_AvgW2V)

prediction_xg = model_xg.predict(test_AvgW2V)

AccuracyScore_xg = accuracy_score(test_labels_AvgW2V, prediction_xg) * 100

print("Accuracy score of XGBoost = "+str(AccuracyScore_xg)+"%")
```

```
Accuracy score of XGBoost = 86.55000000000001%

C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
that an array is not empty.
  if diff:
```

In [50]:

```
Confusion_Matrix = confusion_matrix(test_labels_AvgW2V, prediction_xg)
print("Confusion Matrix on L2 regularization  \n"+str(Confusion_Matrix))
```

```
Confusion Matrix on L2 regularization
[[  79  213]
 [  56 1652]]
```

In [51]:

```
tn, fp, fn, tp = confusion_matrix(test_labels_AvgW2V, prediction_xg).ravel()
tn, fp, fn, tp
```

Out[51]:

```
(79, 213, 56, 1652)
```

2. Average TFIDF-W2V.

In [150]:

```
tfidf_vect = TfidfVectorizer(ngram_range = (1,2))
tfidf = tfidf_vect.fit_transform(Data["ProcessedText"].values)
```

In [151]:

```
print(tfidf.shape)
print(type(tfidf))
```

```
(10000, 230778)
<class 'scipy.sparse.csr.csr_matrix'>
```

In [98]:

```
w2v_Model = gensim.models.Word2Vec(listOfSentences, size=300, min_count=5, workers=4)
```

In [152]:

```
# TF-IDF weighted Word2Vec
tfidf_features = tfidf_vect.get_feature_names()

tfidf_w2v = []
reviews = 0

for sentence in listOfSentences:
    sentenceVector = np.zeros(300)
    weightTfidfSum = 0
    for word in sentence:
        try:
            W2V_Vector = w2v_Model.wv[word]
            tfidfVector = tfidf[reviews, tfidf_features.index(word)]
            sentenceVector += (W2V_Vector * tfidfVector)
            weightTfidfSum += tfidfVector
        except:
            pass
    sentenceVector /= weightTfidfSum
    tfidf_w2v.append(sentenceVector)
    reviews += 1
```

Task 1. Split train and test data in a ratio of 80:20.

In [153]:

```
X_train_TFIDF_W2V, X_test_TFIDF_W2V, Y_train_labels_TFIDF_W2V, Y_test_labels_TFIDF_W2V = train_test_split(tfidf_w2v, Data
```

In [154]:

```
train_TFIDF_W2V = np.array(X_train_TFIDF_W2V)
test_TFIDF_W2V = np.array(X_test_TFIDF_W2V)
train_labels_TFIDF_W2V = np.array(Y_train_labels_TFIDF_W2V)
test_labels_TFIDF_W2V = np.array(Y_test_labels_TFIDF_W2V)
```

In [155]:

```
train_TFIDF_W2V.shape, test_TFIDF_W2V.shape, train_labels_TFIDF_W2V.shape, test_labels_TFIDF_W2V.shape
```

Out[155]:

```
((8000, 300), (2000, 300), (8000,), (2000,))
```

Task 2. Perform GridSearch Cross Validation to find optimal value of number of base models in Random Forest.

In [156]:

```
values = []
for i in range(1, 31, 2):
    values.append(i)

clf = RandomForestClassifier(n_jobs = -1)

hyper_parameters = {'n_estimators': values}
bestScore = GridSearchCV(clf, hyper_parameters, scoring = "accuracy", cv = 3)
bestScore.fit(train_TFIDF_W2V, train_labels_TFIDF_W2V)

print(bestScore.best_estimator_)
```

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
            max_depth=None, max_features='auto', max_leaf_nodes=None,
            min_impurity_decrease=0.0, min_impurity_split=None,
            min_samples_leaf=1, min_samples_split=2,
            min_weight_fraction_leaf=0.0, n_estimators=19, n_jobs=-1,
            oob_score=False, random_state=None, verbose=0,
            warm_start=False)
```

In [157]:

```
best_parameter = bestScore.best_params_
bp = best_parameter["n_estimators"]
bp
```

Out[157]:

```
19
```

In [158]:

```
scoreData = bestScore.grid_scores_
scoreData
```

Out[158]:

```
[mean: 0.76875, std: 0.01000, params: {'n_estimators': 1},
 mean: 0.80850, std: 0.00427, params: {'n_estimators': 3},
 mean: 0.83462, std: 0.00339, params: {'n_estimators': 5},
 mean: 0.83425, std: 0.00236, params: {'n_estimators': 7},
 mean: 0.84462, std: 0.00230, params: {'n_estimators': 9},
 mean: 0.84588, std: 0.00193, params: {'n_estimators': 11},
 mean: 0.84975, std: 0.00361, params: {'n_estimators': 13},
 mean: 0.84688, std: 0.00181, params: {'n_estimators': 15},
 mean: 0.85037, std: 0.00317, params: {'n_estimators': 17},
 mean: 0.85362, std: 0.00073, params: {'n_estimators': 19},
 mean: 0.85275, std: 0.00297, params: {'n_estimators': 21},
 mean: 0.85137, std: 0.00131, params: {'n_estimators': 23},
 mean: 0.84888, std: 0.00280, params: {'n_estimators': 25},
 mean: 0.85125, std: 0.00277, params: {'n_estimators': 27},
 mean: 0.85362, std: 0.00154, params: {'n_estimators': 29}]
```

In [159]:

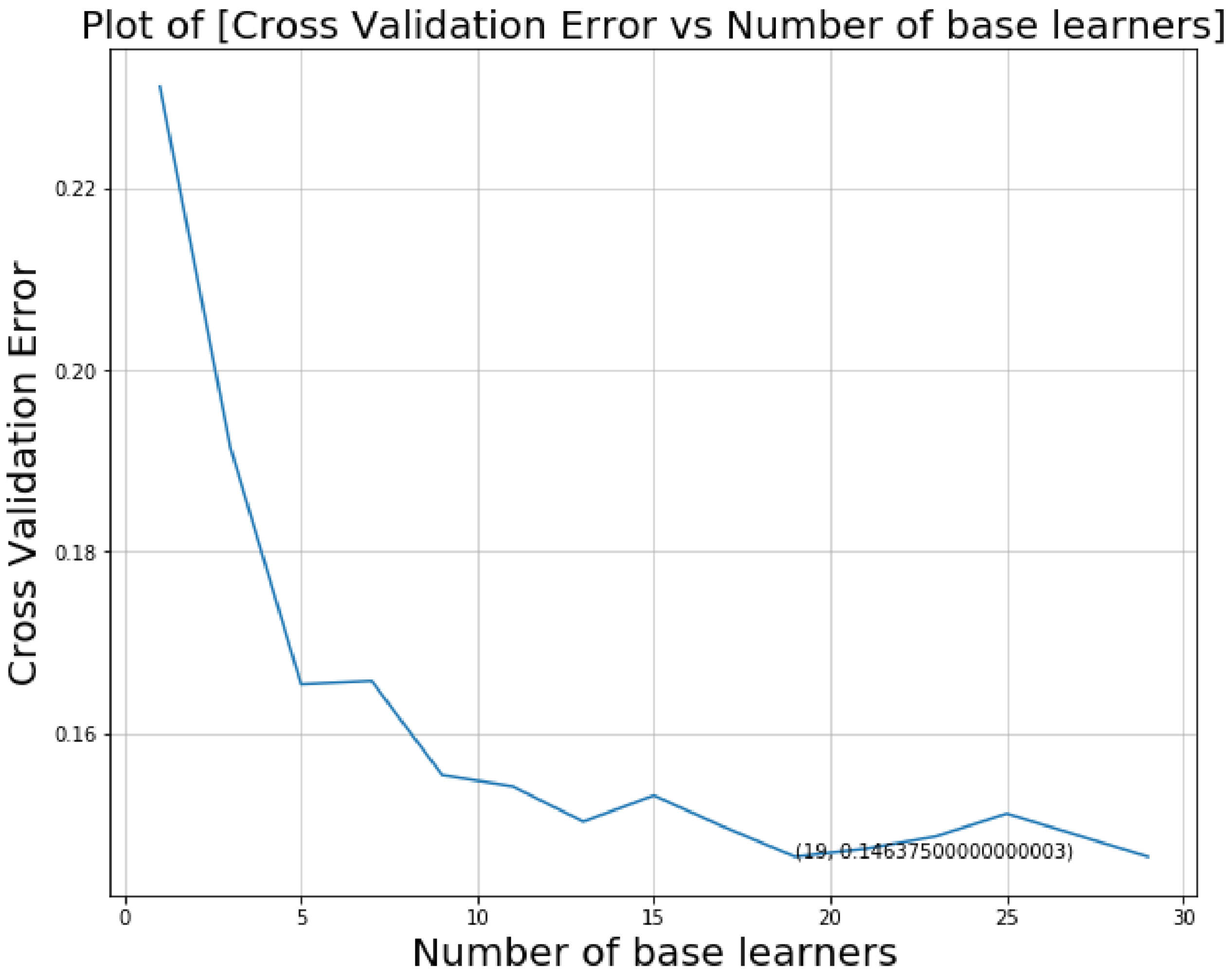
```
error = []
parameter = []
for i in range(len(scoreData)):
    error.append(1 - scoreData[i][1])
    parameter.append(scoreData[i][0]["n_estimators"])

plt.figure(figsize=(10,8))
plt.plot(parameter, error)

plt.title("Plot of [Cross Validation Error vs Number of base learners]", fontsize=20)
plt.xlabel("Number of base learners", fontsize=20)
plt.ylabel("Cross Validation Error", fontsize=20)
plt.grid(linestyle='-', linewidth=0.5)

errorMin = min(error)
errorMin

for xy in zip(parameter, error):
    if xy == (bp, errorMin):
        plt.annotate(xy, xy)
```



Task 3. Apply Random Forest and report accuracy. Also check for train error.

In [160]:

```
#First checking for train error
model_rf_tr = RandomForestClassifier(n_estimators = bp, n_jobs = -1)

model_rf_tr.fit(train_TFIDF_W2V, train_labels_TFIDF_W2V)

prediction_TFIDF_W2V_rf_tr = model_rf_tr.predict(train_TFIDF_W2V)

AccuracyScore_TFIDF_W2V_rf_tr = accuracy_score(train_labels_TFIDF_W2V, prediction_TFIDF_W2V_rf_tr)

print("Train error of Random Forest = "+str(np.round(((1 - AccuracyScore_TFIDF_W2V_rf_tr) * 100), 4))+"%")
```

```
Train error of Random Forest = 0.225%
```

In [161]:

```
model_rf = RandomForestClassifier(n_estimators = bp, n_jobs = -1)

model_rf.fit(train_TFIDF_W2V, train_labels_TFIDF_W2V)

prediction_TFIDF_W2V_rf = model_rf.predict(test_TFIDF_W2V)

AccuracyScore_TFIDF_W2V_rf = accuracy_score(test_labels_TFIDF_W2V, prediction_TFIDF_W2V_rf) * 100

print("Accuracy score of Random Forest = "+str(AccuracyScore_TFIDF_W2V_rf)+"%")
```

```
Accuracy score of Random Forest = 84.1%
```

In [162]:

```
Confusion_Matrix = confusion_matrix(test_labels_TFIDF_W2V, prediction_TFIDF_W2V_rf)
print("Confusion Matrix on L2 regularization  \n"+str(Confusion_Matrix))
```

```
Confusion Matrix on L2 regularization
[[  53  272]
 [  46 1629]]
```

In [163]:

```
tn, fp, fn, tp = confusion_matrix(test_labels_TFIDF_W2V, prediction_TFIDF_W2V_rf).ravel()
tn, fp, fn, tp
```

Out[163]:

```
(53, 272, 46, 1629)
```

Task 4. Perform GridSearch Cross Validation to find optimal number of base models and optimal value of depth of decision tree base models in XGBoost.

In [164]:
```
xgb_model = xgb.XGBClassifier()

hyperParameters = {'max_depth':[1, 2, 3, 4], 'n_estimators':[30, 50, 70, 100]}

clf = GridSearchCV(estimator = xgb_model, param_grid = hyperParameters, scoring='accuracy', cv=3)
clf.fit(train_TFIDF_W2V, train_labels_TFIDF_W2V)

print(clf.best_estimator_)
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
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  if diff:
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that an array is not empty.
  if diff:
```

```
C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
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```
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an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
that an array is not empty.
  if diff:
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
       colsample_bytree=1, gamma=0, learning_rate=0.1, max_delta_step=0,
       max_depth=4, min_child_weight=1, missing=None, n_estimators=70,
       n_jobs=1, nthread=None, objective='binary:logistic', random_state=0,
       reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
       silent=True, subsample=1)
```

In [165]:

```
best_parameter = clf.best_params_
best_parameter
```

Out[165]:

```
{'max_depth': 4, 'n_estimators': 70}
```

In [166]:

```
scoreData = clf.grid_scores_
scoreData
```

Out[166]:

```
[mean: 0.84500, std: 0.00012, params: {'max_depth': 1, 'n_estimators': 30},
 mean: 0.84500, std: 0.00012, params: {'max_depth': 1, 'n_estimators': 50},
 mean: 0.84950, std: 0.00154, params: {'max_depth': 1, 'n_estimators': 70},
 mean: 0.85175, std: 0.00108, params: {'max_depth': 1, 'n_estimators': 100},
 mean: 0.84975, std: 0.00204, params: {'max_depth': 2, 'n_estimators': 30},
 mean: 0.85488, std: 0.00157, params: {'max_depth': 2, 'n_estimators': 50},
 mean: 0.85675, std: 0.00294, params: {'max_depth': 2, 'n_estimators': 70},
 mean: 0.85888, std: 0.00327, params: {'max_depth': 2, 'n_estimators': 100},
 mean: 0.85600, std: 0.00245, params: {'max_depth': 3, 'n_estimators': 30},
 mean: 0.85813, std: 0.00413, params: {'max_depth': 3, 'n_estimators': 50},
 mean: 0.85950, std: 0.00468, params: {'max_depth': 3, 'n_estimators': 70},
 mean: 0.86150, std: 0.00348, params: {'max_depth': 3, 'n_estimators': 100},
 mean: 0.85788, std: 0.00277, params: {'max_depth': 4, 'n_estimators': 30},
 mean: 0.86087, std: 0.00370, params: {'max_depth': 4, 'n_estimators': 50},
 mean: 0.86413, std: 0.00645, params: {'max_depth': 4, 'n_estimators': 70},
 mean: 0.86200, std: 0.00447, params: {'max_depth': 4, 'n_estimators': 100}]
```

In [167]:

```
error = []
eachError = []
for i in range(len(scoreData)):
    eachError.append(np.round((1 - scoreData[i][1]), 4))
    if i == 3 or i == 7 or i == 11 or i == 15:
        error.append(eachError)
        eachError = []
```

In [168]:

```
error
```

Out[168]:

```
[[0.155, 0.155, 0.1505, 0.1482],
 [0.1502, 0.1451, 0.1432, 0.1411],
 [0.144, 0.1419, 0.1405, 0.1385],
 [0.1421, 0.1391, 0.1359, 0.138]]
```

In [169]:
```
columnNames = [30, 50, 70, 100]
```

In [170]:
```
errorFrame = pd.DataFrame(error, columns = columnNames)
```

In [171]:
```
errorFrame
```

Out[171]:

	30	50	70	100
0	0.1550	0.1550	0.1505	0.1482
1	0.1502	0.1451	0.1432	0.1411
2	0.1440	0.1419	0.1405	0.1385
3	0.1421	0.1391	0.1359	0.1380

In [172]:
```
indexNames = [1, 2, 3, 4]
errorFrame["Max_depth"] = indexNames
```

In [173]:
```
errorFrame
```

Out[173]:

	30	50	70	100	Max_depth
0	0.1550	0.1550	0.1505	0.1482	1
1	0.1502	0.1451	0.1432	0.1411	2
2	0.1440	0.1419	0.1405	0.1385	3
3	0.1421	0.1391	0.1359	0.1380	4

In [174]:
```
errorFrame.set_index("Max_depth", append = False, drop = True, inplace = True)
```

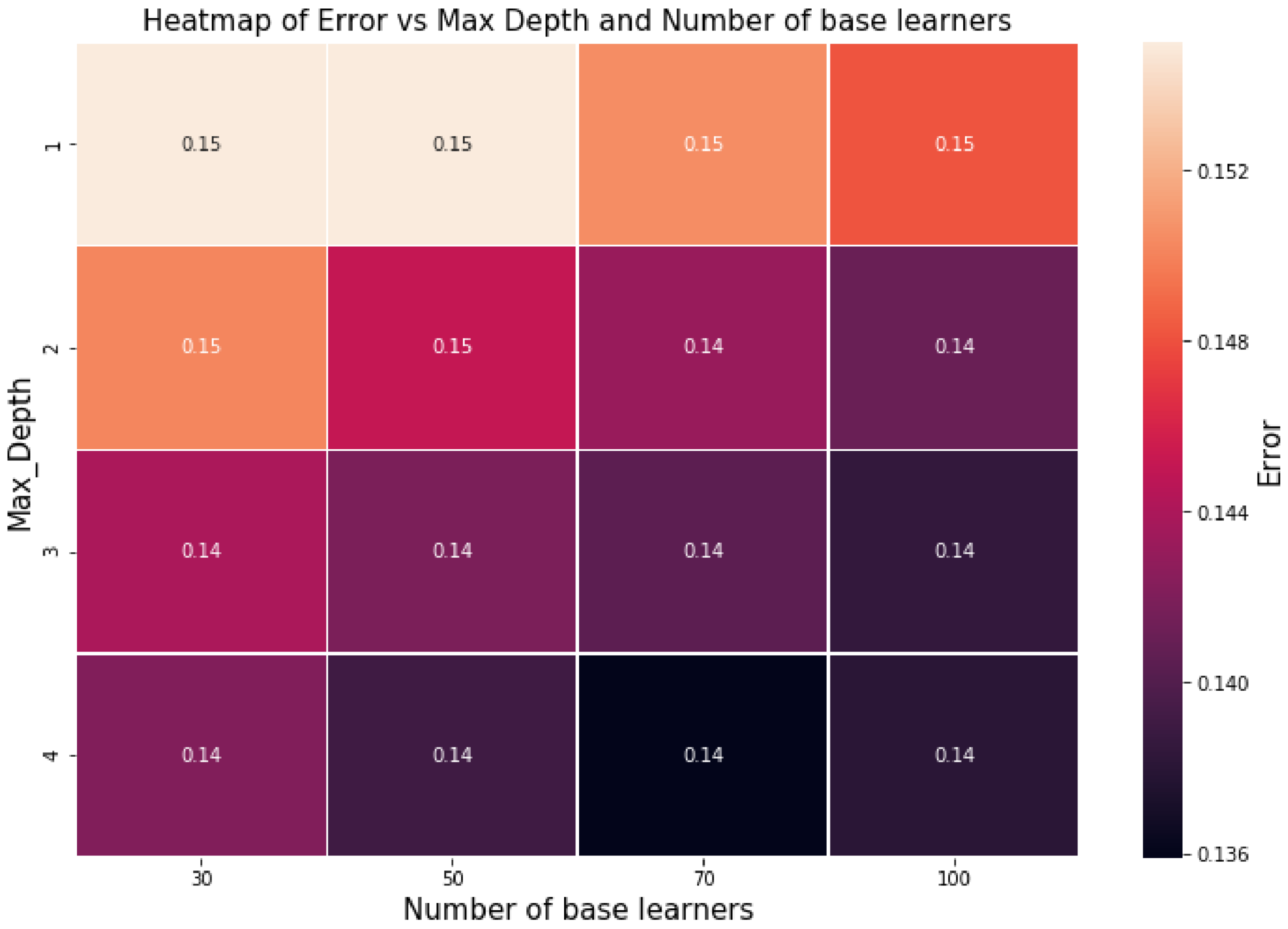
In [175]:
```
errorFrame
```

Out[175]:

	30	50	70	100
Max_depth				
1	0.1550	0.1550	0.1505	0.1482
2	0.1502	0.1451	0.1432	0.1411
3	0.1440	0.1419	0.1405	0.1385
4	0.1421	0.1391	0.1359	0.1380

```
In [176]: plt.figure(figsize=(12, 8))
          plt.title("Heatmap of Error vs Max Depth and Number of base learners", size = 15)
          ax = sns.heatmap(errorFrame, annot = True, linewidths=.5)
          ax.figure.axes[0].set_xlabel('Number of base learners', size = 15)
          ax.figure.axes[0].set_ylabel('Max_Depth', size = 15)
          ax.figure.axes[-1].set_ylabel('Error', size = 15)
```

```
Out[176]: Text(738.529,0.5,'Error')
```



Here above in heatmap you can see that the error is minimum when Number of base learners are 70 and Max_Depth value is 4. Therefore,

from grid search we are considering our Number of base learners value as 70 and Max_Depth Value as 4.

Task 5. Apply XGBoost and report accuracy. Also check for train error.

In [177]:

```
#checking for train error
model_xg_tr = xgb.XGBClassifier(max_depth = 4, n_estimators = 70)

model_xg_tr.fit(train_TFIDF_W2V, train_labels_TFIDF_W2V)

prediction_TFIDF_W2V_xg_tr = model_xg_tr.predict(train_TFIDF_W2V)

AccuracyScore_TFIDF_W2V_xg_tr = accuracy_score(train_labels_TFIDF_W2V, prediction_TFIDF_W2V_xg_tr)

print("Train Error of XGBoost = "+str((1 - AccuracyScore_TFIDF_W2V_xg_tr) * 100)+"%")
```

```
Train Error of XGBoost = 10.099999999999998%

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an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
that an array is not empty.
  if diff:
```

In [179]:

```
model_xg = xgb.XGBClassifier(max_depth = 4, n_estimators = 70)

model_xg.fit(train_TFIDF_W2V, train_labels_TFIDF_W2V)

prediction_xg = model_xg.predict(test_TFIDF_W2V)

AccuracyScore_xg = accuracy_score(test_labels_TFIDF_W2V, prediction_xg) * 100

print("Accuracy score of XGBoost = "+str(AccuracyScore_xg)+"%")
```

```
Accuracy score of XGBoost = 84.65%

C:\Users\GauravP\Anaconda3\lib\site-packages\sklearn\preprocessing\label.py:151: DeprecationWarning: The truth value of
an empty array is ambiguous. Returning False, but in future this will result in an error. Use `array.size > 0` to check
that an array is not empty.
  if diff:
```

In [180]:

```
Confusion_Matrix = confusion_matrix(test_labels_TFIDF_W2V, prediction_xg)
print("Confusion Matrix on L2 regularization  \n"+str(Confusion_Matrix))
```

```
Confusion Matrix on L2 regularization
[[  64  261]
 [  46 1629]]
```

In [181]:

```
tn, fp, fn, tp = confusion_matrix(test_labels_TFIDF_W2V, prediction_xg).ravel()
tn, fp, fn, tp
```

Out[181]:

```
(64, 261, 46, 1629)
```

Summary

Avg W2V

1. Optimal Value of number of base learners in Random Forest from Grid Search = 29
2. Train Error in Random Forest = 0.1%
3. Accuracy of Random Forest = 85.25%
4. Optimal Value of number of base learners and maximum depth of base learners in XGBoost from Grid Search = 100 & 4
5. Train Error in XGBoost 8.11%
6. Accuracy of XGBoost = 86.55%

TFIDF-W2V

1. Optimal Value of number of base learners in Random Forest from Grid Search = 19
2. Train Error in Random Forest = 0.225%
3. Accuracy of Random Forest = 84.1%
4. Optimal Value of number of base learners and maximum depth of base learners in XGBoost from Grid Search = 70 & 4
5. Train Error in XGBoost 10.09%
6. Accuracy of XGBoost = 84.65%