Quora Question Pair Similarity

In [129]:

```
import warnings
warnings.filterwarnings("ignore")
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from subprocess import check_output
%matplotlib inline
import plotly.offline as py
py.init_notebook_mode(connected=True)
import plotly.graph_objs as go
import plotly.tools as tls
import os
import gc

import re
from nltk.corpus import stopwords
import distance
from nltk.stem import PorterStemmer
from bs4 import BeautifulSoup
import re
from nltk.corpus import stopwords
# This package is used for finding longest common subsequence between two strings
# you can write your own dp code for this
import distance
from nltk.stem import PorterStemmer
from bs4 import BeautifulSoup
from fuzzywuzzy import fuzz
from sklearn.manifold import TSNE
# Import the Required lib packages for WORD-Cloud generation
# https://stackoverflow.com/questions/45625434/how-to-install-wordcloud-in-python3-6
from wordcloud import WordCloud, STOPWORDS
from os import path
from PIL import Image
```

In [130]:

```
import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
import sqlite3
from sqlalchemy import create_engine # database connection
import csv
import os
warnings.filterwarnings("ignore")
import datetime as dt
import numpy as np
from nltk.corpus import stopwords
from sklearn.decomposition import TruncatedSVD
from sklearn.preprocessing import normalize
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.manifold import TSNE
import seaborn as sns
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import confusion_matrix
from sklearn.metrics.classification import accuracy_score, log_loss
from sklearn.feature_extraction.text import TfidfVectorizer
from collections import Counter
from scipy.sparse import hstack
from sklearn.multiclass import OneVsRestClassifier
from sklearn.svm import SVC
from sklearn.model_selection import StratifiedKFold
from collections import Counter, defaultdict
from sklearn.calibration import CalibratedClassifierCV
from sklearn.naive_bayes import MultinomialNB
from sklearn.naive_bayes import GaussianNB
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
import math
from sklearn.metrics import normalized_mutual_info_score
from sklearn.ensemble import RandomForestClassifier



from sklearn.model_selection import cross_val_score
from sklearn.linear_model import SGDClassifier
from mlxtend.classifier import StackingClassifier

from sklearn import model_selection
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import precision_recall_curve, auc, roc_curve
```

Basic Feature Extraction (before cleaning)

Let us now construct a few features like:

- **freq_qid1** = Frequency of qid1's
- **freq_qid2** = Frequency of qid2's
- **q1len** = Length of q1
- **q2len** = Length of q2
- **q1_n_words** = Number of words in Question 1
- **q2_n_words** = Number of words in Question 2
- **word_Common** = (Number of common unique words in Question 1 and Question 2)
- **word_Total** =(Total num of words in Question 1 + Total num of words in Question 2)
- **word_share** = (word_common)/(word_Total)
- **freq_q1+freq_q2** = sum total of frequency of qid1 and qid2
- **freq_q1-freq_q2** = absolute difference of frequency of qid1 and qid2

Random train test split(70:30)

We need to split the data before feature extraction because then there would be problem of data leakage otherwise.

In [185]:

```
data = pd.read_csv("train.csv")
```

In [186]:

```
data.head()
```

Out[186]:

	id	qid1	qid2	question1	question2	is_duplicate
0	0	1	2	What is the step by step guide to invest in sh...	What is the step by step guide to invest in sh...	0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0
3	3	7	8	Why am I mentally very lonely? How can I solve...	Find the remainder when [math]23^{24}[/math] i...	0
4	4	9	10	Which one dissolve in water quikly sugar, salt...	Which fish would survive in salt water?	0

In [187]:

```
data.shape
```

Out[187]:

```
(404290, 6)
```

In [188]:

```
data = data.dropna()
```

In [ ]:

```

```

In [189]:

```
data.shape
```

Out[189]:

```
(404287, 6)
```

In [190]:

```
data = data[data.question1 != df_train_advanced.iloc[12530]["question1"]]
```

In [191]:

```
data.shape
```

Out[191]:

```
(404287, 6)
```

In [192]:

```
data.drop(data[data['question1'] == df_train_advanced.iloc[12530]["question1"]].index,
inplace = True)
```

In [146]:

```
data.drop(data[data['question2'] == ""].index, inplace = True)
```

In [193]:

```
data.shape
```

Out[193]:

```
(404287, 6)
```

In [66]:

```
type(data["is_duplicate"][5])
```

Out[66]:

```
numpy.int64
```

In [67]:

```
y_true = data['is_duplicate']
data.drop(['is_duplicate'], axis=1, inplace=True)
```

In [68]:

```
data.shape
```

Out[68]:

```
(404287, 5)
```

In [ ]:

```

```

In [69]:

```
X_train,X_test, y_train, y_test = train_test_split(data, y_true, stratify=y_true, test_
size=0.3)
```

In [70]:

```
X_train.shape
```

Out[70]:

```
(283000, 5)
```

In [71]:

```
X_test.shape
```

Out[71]:

```
(121287, 5)
```

In [72]:

```
X_train.head()
```

Out[72]:

	id	qid1	qid2	question1	question2
307323	307323	430984	430985	Why haven't more car companies used CVCC techn...	Why haven't more car companies used CVCC techn...
34363	34363	14381	62970	Is it normal to fall out of love?	How do I fall out of love with someone?
98028	98028	87590	162974	Cash: How much USD can I legally carry on my p...	How much cash can you keep at home legally in ...
251666	251666	365834	365835	What were major contributions of the Assyrian?	What were the Assyrians' major contributions t...
152166	152166	239124	239125	What is the coolest scientific "experiment" on...	What is the coolest science experiment to do a...

Training Data : Applying basic feature extraction on the Training data

In [73]:

```
X_train['freq_qid1'] = X_train.groupby('qid1')['qid1'].transform('count')
X_train['freq_qid2'] = X_train.groupby('qid2')['qid2'].transform('count')
X_train['q1len'] = X_train['question1'].str.len()
X_train['q2len'] = X_train['question2'].str.len()
X_train['q1_n_words'] = X_train['question1'].apply(lambda row: len(row.split(" ")))
X_train['q2_n_words'] = X_train['question2'].apply(lambda row: len(row.split(" ")))

def normalized_word_Common(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return 1.0 * len(w1 & w2)
X_train['word_Common'] = X_train.apply(normalized_word_Common, axis=1)

def normalized_word_Total(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return 1.0 * (len(w1) + len(w2))
X_train['word_Total'] = X_train.apply(normalized_word_Total, axis=1)

def normalized_word_share(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return 1.0 * len(w1 & w2)/(len(w1) + len(w2))
X_train['word_share'] = X_train.apply(normalized_word_share, axis=1)

X_train['freq_q1+q2'] = X_train['freq_qid1']+X_train['freq_qid2']
X_train['freq_q1-q2'] = abs(X_train['freq_qid1']-X_train['freq_qid2'])

X_train.to_csv("df_fe_without_preprocessing_train_self.csv", index=False)

X_train.head()
```

Out[73]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2le
307323	307323	430984	430985	Why haven't more car companies used CVCC techn...	Why haven't more car companies used CVCC techn...	1	1	66	5
34363	34363	14381	62970	Is it normal to fall out of love?	How do I fall out of love with someone?	5	6	33	3
98028	98028	87590	162974	Cash: How much USD can I legally carry on my p...	How much cash can you keep at home legally in ...	3	1	91	5
251666	251666	365834	365835	What were major contributions of the Assyrian?	What were the Assyrians' major contributions t...	1	1	46	6
152166	152166	239124	239125	What is the coolest scientific "experiment" on...	What is the coolest science experiment to do a...	2	1	70	5

Test Data : Applying basic feature extraction on the Test data

In [74]:

```
X_test['freq_qid1'] = X_test.groupby('qid1')['qid1'].transform('count')
X_test['freq_qid2'] = X_test.groupby('qid2')['qid2'].transform('count')
X_test['q1len'] = X_test['question1'].str.len()
X_test['q2len'] = X_test['question2'].str.len()
X_test['q1_n_words'] = X_test['question1'].apply(lambda row: len(row.split(" ")))
X_test['q2_n_words'] = X_test['question2'].apply(lambda row: len(row.split(" ")))

def normalized_word_Common(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return 1.0 * len(w1 & w2)
X_test['word_Common'] = X_test.apply(normalized_word_Common, axis=1)

def normalized_word_Total(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return 1.0 * (len(w1) + len(w2))
X_test['word_Total'] = X_test.apply(normalized_word_Total, axis=1)

def normalized_word_share(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return 1.0 * len(w1 & w2)/(len(w1) + len(w2))
X_test['word_share'] = X_test.apply(normalized_word_share, axis=1)

X_test['freq_q1+q2'] = X_test['freq_qid1']+X_test['freq_qid2']
X_test['freq_q1-q2'] = abs(X_test['freq_qid1']-X_test['freq_qid2'])

X_test.to_csv("df_fe_without_preprocessing_test_self.csv", index=False)

X_test.head()
```

Out[74]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q
175087	175087	176590	269669	What are numbers? Do numbers exist? Where are ...	What are numbers? Do numbers exist?	1	1	91	35	
347894	347894	476403	476404	How is Victoria Beckham involved with Victoria...	Why are Victoria Secret models so old, in comp...	1	1	56	77	
152745	152745	239913	239914	How genuine were the business leaders and cele...	Anyone has an idea about samsung J5570 tv mode...	1	1	112	136	
205968	205968	96410	44271	What kinds of thing can young people learn fro...	What could young people learn from old people?	2	3	59	46	
60393	60393	105617	90554	Where can I get real active Instagram followers?	What is the best way to get real Instagram fol...	2	3	48	53	

Advanced feature extraction

In [75]:

```
import warnings
warnings.filterwarnings("ignore")
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
from subprocess import check_output
%matplotlib inline
import plotly.offline as py
py.init_notebook_mode(connected=True)
import plotly.graph_objs as go
import plotly.tools as tls
import os
import gc

import re
from nltk.corpus import stopwords
import distance
from nltk.stem import PorterStemmer
from bs4 import BeautifulSoup
import re
from nltk.corpus import stopwords
# This package is used for finding longest common subsequence between two strings
# you can write your own dp code for this
import distance
from nltk.stem import PorterStemmer
from bs4 import BeautifulSoup
from fuzzywuzzy import fuzz
from sklearn.manifold import TSNE
# Import the Required lib packages for WORD-Cloud generation
# https://stackoverflow.com/questions/45625434/how-to-install-wordcloud-in-python3-6
from wordcloud import WordCloud, STOPWORDS
from os import path
from PIL import Image
```

Training data

In [76]:

```
#https://stackoverflow.com/questions/12468179/unicodedecodeerror-utf8-codec-cant-decode-byte-0x9c
if os.path.isfile('df_fe_without_preprocessing_train_self.csv'):
    df_train = pd.read_csv("df_fe_without_preprocessing_train_self.csv",encoding='latin-1')
    df_train = df_train.fillna('')
    df_train.head()
else:
    print("get df_fe_without_preprocessing_train.csv from drive or run the previous notebook")
```

In [77]:

```
df_train.head()
```

Out[77]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1
0	307323	430984	430985	Why haven't more car companies used CVCC techn...	Why haven't more car companies used CVCC techn...	1	1	66	52	
1	34363	14381	62970	Is it normal to fall out of love?	How do I fall out of love with someone?	5	6	33	39	
2	98028	87590	162974	Cash: How much USD can I legally carry on my p...	How much cash can you keep at home legally in ...	3	1	91	52	
3	251666	365834	365835	What were major contributions of the Assyrian?	What were the Assyrians' major contributions t...	1	1	46	61	
4	152166	239124	239125	What is the coolest scientific "experiment" on...	What is the coolest science experiment to do a...	2	1	70	53	

In [78]:

```
df_train.shape
```

Out[78]:

```
(283000, 16)
```

Test data

In [79]:

```
#https://stackoverflow.com/questions/12468179/unicodedecodeerror-utf8-codec-cant-decode-byte-0x9c
if os.path.isfile('df_fe_without_preprocessing_test_self.csv'):
    df_test = pd.read_csv("df_fe_without_preprocessing_test_self.csv",encoding='latin-1')
    df_test = df_test.fillna('')
    df_test.head()
else:
    print("get df_fe_without_preprocessing_train.csv from drive or run the previous notebook")
```

In [80]:

```
df_test.head()
```

Out[80]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1_n_v
0	175087	176590	269669	What are numbers? Do numbers exist? Where are ...	What are numbers? Do numbers exist?	1	1	91	35	
1	347894	476403	476404	How is Victoria Beckham involved with Victoria...	Why are Victoria Secret models so old, in comp...	1	1	56	77	
2	152745	239913	239914	How genuine were the business leaders and cele...	Anyone has an idea about samsung J5570 tv mode...	1	1	112	136	
3	205968	96410	44271	What kinds of thing can young people learn fro...	What could young people learn from old people?	2	3	59	46	
4	60393	105617	90554	Where can I get real active Instagram followers?	What is the best way to get real Instagram fol...	2	3	48	53	

In [81]:

```
df_test.shape
```

Out[81]:

```
(121287, 16)
```

Preprocessing of Text

- Preprocessing:
  - Removing html tags
  - Removing Punctuations
  - Performing stemming
  - Removing Stopwords
  - Expanding contractions etc.

Training data

In [82]:

```
# Function to Compute and get the features : With 2 parameters of Question 1 and Questi
on 2

# To get the results in 4 decemal points
SAFE_DIV = 0.0001

STOP_WORDS = stopwords.words("english")


def preprocess(x):
    x = str(x).lower()
    x = x.replace(",000,000", "m").replace(",000", "k").replace("’", "'").replace("’",
"'")\
                           .replace("won't", "will not").replace("cannot", "can not").r
eplace("can't", "can not")\
                           .replace("n't", " not").replace("what's", "what is").replace
("it's", "it is")\
                           .replace("'ve", " have").replace("i'm", "i am").replace("'r
e", " are")\
                           .replace("he's", "he is").replace("she's", "she is").replace
("'s", " own")\
                           .replace("%", " percent ").replace("₹", " rupee ").replace(
"$", " dollar ")\
                           .replace("€", " euro ").replace("'ll", " will")
    x = re.sub(r"([0-9]+)000000", r"\1m", x)
    x = re.sub(r"([0-9]+)000", r"\1k", x)


    porter = PorterStemmer()
    pattern = re.compile('\W')

    if type(x) == type(''):
        x = re.sub(pattern, ' ', x)


    if type(x) == type(''):
        x = porter.stem(x)
        example1 = BeautifulSoup(x)
        x = example1.get_text()


    return x
```

Advanced Feature Extraction (NLP and Fuzzy Features)

Definition:

- **Token**: You get a token by splitting sentence a space
- **Stop_Word** : stop words as per NLTK.
- **Word** : A token that is not a stop_word

Features:

- **cwc_min** : Ratio of common_word_count to min lenghth of word count of Q1 and Q2
  cwc_min = common_word_count / (min(len(q1_words), len(q2_words))

- **cwc_max** : Ratio of common_word_count to max lenghth of word count of Q1 and Q2
  cwc_max = common_word_count / (max(len(q1_words), len(q2_words))

- **csc_min** : Ratio of common_stop_count to min lenghth of stop count of Q1 and Q2
  csc_min = common_stop_count / (min(len(q1_stops), len(q2_stops))

- **csc_max** : Ratio of common_stop_count to max lenghth of stop count of Q1 and Q2
  csc_max = common_stop_count / (max(len(q1_stops), len(q2_stops))

- **ctc_min** : Ratio of common_token_count to min lenghth of token count of Q1 and Q2
  ctc_min = common_token_count / (min(len(q1_tokens), len(q2_tokens))

- **ctc_max** : Ratio of common_token_count to max lenghth of token count of Q1 and Q2
  ctc_max = common_token_count / (max(len(q1_tokens), len(q2_tokens))

- **last_word_eq** : Check if Last word of both questions is equal or not
  last_word_eq = int(q1_tokens[-1] == q2_tokens[-1])

- **first_word_eq** : Check if First word of both questions is equal or not
  first_word_eq = int(q1_tokens[0] == q2_tokens[0])

- **abs_len_diff** : Abs. length difference
  abs_len_diff = abs(len(q1_tokens) - len(q2_tokens))

- **mean_len** : Average Token Length of both Questions
  mean_len = (len(q1_tokens) + len(q2_tokens))/2

- **fuzz_ratio** : https://github.com/seatgeek/fuzzywuzzy#usage (https://github.com/seatgeek/fuzzywuzzy#usage) http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/ (http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/)

- **fuzz_partial_ratio** : https://github.com/seatgeek/fuzzywuzzy#usage (https://github.com/seatgeek/fuzzywuzzy#usage) http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/ (http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/)

- **token_sort_ratio** : https://github.com/seatgeek/fuzzywuzzy#usage (https://github.com/seatgeek/fuzzywuzzy#usage) http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/ (http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/)

- **token_set_ratio** : https://github.com/seatgeek/fuzzywuzzy#usage (https://github.com/seatgeek/fuzzywuzzy#usage) http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/ (http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/)

- **longest_substr_ratio** : Ratio of length longest common substring to min lenghth of token count of Q1 and Q2
  longest_substr_ratio = len(longest common substring) / (min(len(q1_tokens), len(q2_tokens))

In [83]:

```
def get_token_features(q1, q2):
    token_features = [0.0]*10

    # Converting the Sentence into Tokens:
    q1_tokens = q1.split()
    q2_tokens = q2.split()

    if len(q1_tokens) == 0 or len(q2_tokens) == 0:
        return token_features
    # Get the non-stopwords in Questions
    q1_words = set([word for word in q1_tokens if word not in STOP_WORDS])
    q2_words = set([word for word in q2_tokens if word not in STOP_WORDS])

    #Get the stopwords in Questions
    q1_stops = set([word for word in q1_tokens if word in STOP_WORDS])
    q2_stops = set([word for word in q2_tokens if word in STOP_WORDS])

    # Get the common non-stopwords from Question pair
    common_word_count = len(q1_words.intersection(q2_words))

    # Get the common stopwords from Question pair
    common_stop_count = len(q1_stops.intersection(q2_stops))

    # Get the common Tokens from Question pair
    common_token_count = len(set(q1_tokens).intersection(set(q2_tokens)))


    token_features[0] = common_word_count / (min(len(q1_words), len(q2_words)) + SAFE_D
IV)
    token_features[1] = common_word_count / (max(len(q1_words), len(q2_words)) + SAFE_D
IV)
    token_features[2] = common_stop_count / (min(len(q1_stops), len(q2_stops)) + SAFE_D
IV)
    token_features[3] = common_stop_count / (max(len(q1_stops), len(q2_stops)) + SAFE_D
IV)
    token_features[4] = common_token_count / (min(len(q1_tokens), len(q2_tokens)) + SAF
E_DIV)
    token_features[5] = common_token_count / (max(len(q1_tokens), len(q2_tokens)) + SAF
E_DIV)

    # Last word of both question is same or not
    token_features[6] = int(q1_tokens[-1] == q2_tokens[-1])

    # First word of both question is same or not
    token_features[7] = int(q1_tokens[0] == q2_tokens[0])

    token_features[8] = abs(len(q1_tokens) - len(q2_tokens))

    #Average Token Length of both Questions
    token_features[9] = (len(q1_tokens) + len(q2_tokens))/2
    return token_features

# get the Longest Common sub string

def get_longest_substr_ratio(a, b):
    strs = list(distance.lcsubstrings(a, b))
    if len(strs) == 0:
        return 0
    else:
```

```
        return len(strs[0]) / (min(len(a), len(b)) + 1)

def extract_features(df):
    # preprocessing each question
    df["question1"] = df["question1"].fillna("").apply(preprocess)
    df["question2"] = df["question2"].fillna("").apply(preprocess)

    print("token features...")

    # Merging Features with dataset

    token_features = df.apply(lambda x: get_token_features(x["question1"], x["question
2"]), axis=1)

    df["cwc_min"]       = list(map(lambda x: x[0], token_features))
    df["cwc_max"]       = list(map(lambda x: x[1], token_features))
    df["csc_min"]       = list(map(lambda x: x[2], token_features))
    df["csc_max"]       = list(map(lambda x: x[3], token_features))
    df["ctc_min"]       = list(map(lambda x: x[4], token_features))
    df["ctc_max"]       = list(map(lambda x: x[5], token_features))
    df["last_word_eq"]  = list(map(lambda x: x[6], token_features))
    df["first_word_eq"] = list(map(lambda x: x[7], token_features))
    df["abs_len_diff"]  = list(map(lambda x: x[8], token_features))
    df["mean_len"]      = list(map(lambda x: x[9], token_features))

    #Computing Fuzzy Features and Merging with Dataset

    # do read this blog: http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching
-in-python/
    # https://stackoverflow.com/questions/31806695/when-to-use-which-fuzz-function-to-c
ompare-2-strings
    # https://github.com/seatgeek/fuzzywuzzy
    print("fuzzy features..")

    df["token_set_ratio"]       = df.apply(lambda x: fuzz.token_set_ratio(x["question1"
], x["question2"]), axis=1)
    # The token sort approach involves tokenizing the string in question, sorting the t
okens alphabetically, and
    # then joining them back into a string We then compare the transformed strings with
a simple ratio().
    df["token_sort_ratio"]      = df.apply(lambda x: fuzz.token_sort_ratio(x["question
1"], x["question2"]), axis=1)
    df["fuzz_ratio"]            = df.apply(lambda x: fuzz.QRatio(x["question1"], x["que
stion2"]), axis=1)
    df["fuzz_partial_ratio"]    = df.apply(lambda x: fuzz.partial_ratio(x["question1"],
x["question2"]), axis=1)
    df["longest_substr_ratio"]  = df.apply(lambda x: get_longest_substr_ratio(x["questi
on1"], x["question2"]), axis=1)
    return df
```

In [84]:

```
if os.path.isfile('nlp_features_train_self.csv'):
    df_train_advanced = pd.read_csv("nlp_features_train_self.csv",encoding='latin-1')
    df_train_advanced.fillna(' ')
else:
    print("Extracting features for train:")
    #df_train = pd.read_csv("train.csv")
    df_train_advanced = extract_features(df_train)
    df_train_advanced.to_csv("nlp_features_train_self.csv", index=False)
df_train_advanced.head(2)
```

```
Extracting features for train:
token features...
fuzzy features..
```

Out[84]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1_n_
0	307323	430984	430985	why have not more car companies used cvcc tech...	why have not more car companies used cvcc tech...	1	1	66	52	
1	34363	14381	62970	is it normal to fall out of love	how do i fall out of love with someone	5	6	33	39	

2 rows × 31 columns

Test data

In [85]:

```
if os.path.isfile('nlp_features_test_self.csv'):
    df_test_advanced = pd.read_csv("nlp_features_test_self.csv",encoding='latin-1')
    df_test_advanced.fillna('')
else:
    print("Extracting features for train:")
    #df_train = pd.read_csv("train.csv")
    df_test_advanced = extract_features(df_test)
    df_test_advanced.to_csv("nlp_features_test_self.csv", index=False)
df_test_advanced.head(2)
```

```
Extracting features for train:
token features...
fuzzy features..
```

Out[85]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1_n_
0	175087	176590	269669	what are numbers do numbers exist where are ...	what are numbers do numbers exist	1	1	91	35	
1	347894	476403	476404	how is victoria beckham involved with victoria...	why are victoria secret models so old in comp...	1	1	56	77	

2 rows × 31 columns

Now we have two features in the form of text but for any machine learning model we need to pass data in the form of numerical data hence we will be converting it into the vectors form usinf tfidf vectorizer.

Featurizing text data with tfidf vectors

In [86]:

```
# avoid decoding problems


# encode questions to unicode
# https://stackoverflow.com/a/6812069
# ----------------- python 2 ---------------------
# df['question1'] = df['question1'].apply(lambda x: unicode(str(x),"utf-8"))
# df['question2'] = df['question2'].apply(lambda x: unicode(str(x),"utf-8"))
# ----------------- python 3 ---------------------

#train data
df_train_advanced['question1'] = df_train_advanced['question1'].apply(lambda x: str(x))
df_train_advanced['question2'] = df_train_advanced['question2'].apply(lambda x: str(x))

# test data

df_test_advanced['question1'] = df_test_advanced['question1'].apply(lambda x: str(x))
df_test_advanced['question2'] = df_test_advanced['question2'].apply(lambda x: str(x))
```

In [ ]:

```

```

In [87]:

```
from sklearn.feature_extraction.text import TfidfVectorizer

#training data

ques_set_1_train = list(df_train_advanced['question1'])
ques_set_2_train = list(df_train_advanced['question2'])

tfidf_ques_set_1_train = TfidfVectorizer(lowercase=False,)
tfidf_ques_set_2_train = TfidfVectorizer(lowercase=False,)

tfidf_ques_set_1_vectorized_train = tfidf_ques_set_1_train.fit_transform(ques_set_1_tra
in)
tfidf_ques_set_2_vectorized_train = tfidf_ques_set_2_train.fit_transform(ques_set_2_tra
in)

#test data

ques_set_1_test = list(df_test_advanced['question1'])
ques_set_2_test = list(df_test_advanced['question2'])



tfidf_ques_set_1_vectorized_test = tfidf_ques_set_1_train.transform(ques_set_1_test)
tfidf_ques_set_2_vectorized_test = tfidf_ques_set_2_train.transform(ques_set_2_test)

print(tfidf_ques_set_1_vectorized_train.shape,y_train.shape)
print(tfidf_ques_set_2_vectorized_train.shape,y_train.shape)
print(tfidf_ques_set_1_vectorized_test.shape,y_test.shape)
print(tfidf_ques_set_2_vectorized_test.shape,y_test.shape)
```

```
(283000, 59181) (283000,)
(283000, 54624) (283000,)
(121287, 59181) (121287,)
(121287, 54624) (121287,)
```

Dropping the unnecessary features now and creating the final data set for our model.

In [88]:

```
prefinal_data_train = df_train_advanced.drop(['qid1','qid2', 'id','question1','question
2'],axis=1)

prefinal_data_test = df_test_advanced.drop(['qid1','qid2', 'id','question1','question2'
],axis=1)

final_data_train = hstack((tfidf_ques_set_1_vectorized_train,tfidf_ques_set_2_vectorize
d_train,prefinal_data_train))

final_data_test = hstack((tfidf_ques_set_1_vectorized_test,tfidf_ques_set_2_vectorized_
test,prefinal_data_test))
```

In [89]:

```
print(prefinal_data_train.shape)
```

(283000, 26)

In [90]:

```
print(final_data_train.shape)
```

(283000, 113831)

In [91]:

```
print(prefinal_data_test.shape)
```

(121287, 26)

In [92]:

```
print(final_data_test.shape)
```

(121287, 113831)

In [93]:

```
# This function plots the confusion matrices given y_i, y_i_hat.
def plot_confusion_matrix(test_y, predict_y):
    C = confusion_matrix(test_y, predict_y)
    # C = 9,9 matrix, each cell (i,j) represents number of points of class i are predic
ted class j

    A =(((C.T)/(C.sum(axis=1))).T)
    #divid each element of the confusion matrix with the sum of elements in that column

    # C = [[1, 2],
    #     [3, 4]]
    # C.T = [[1, 3],
    #        [2, 4]]
    # C.sum(axis = 1)  axis=0 corresonds to columns and axis=1 corresponds to rows in t
wo diamensional array
    # C.sum(axix =1) = [[3, 7]]
    # ((C.T)/(C.sum(axis=1))) = [[1/3, 3/7]
    #                           [2/3, 4/7]]

    # ((C.T)/(C.sum(axis=1))).T = [[1/3, 2/3]
    #                           [3/7, 4/7]]
    # sum of row elements = 1

    B =(C/C.sum(axis=0))
    #divid each element of the confusion matrix with the sum of elements in that row
    # C = [[1, 2],
    #     [3, 4]]
    # C.sum(axis = 0)  axis=0 corresonds to columns and axis=1 corresponds to rows in t
wo diamensional array
    # C.sum(axix =0) = [[4, 6]]
    # (C/C.sum(axis=0)) = [[1/4, 2/6],
    #                      [3/4, 4/6]]
    plt.figure(figsize=(20,4))

    labels = [1,2]
    # representing A in heatmap format
    cmap=sns.light_palette("blue")
    plt.subplot(1, 3, 1)
    sns.heatmap(C, annot=True, cmap=cmap, fmt=".3f", xticklabels=labels, yticklabels=la
bels)
    plt.xlabel('Predicted Class')
    plt.ylabel('Original Class')
    plt.title("Confusion matrix")

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

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

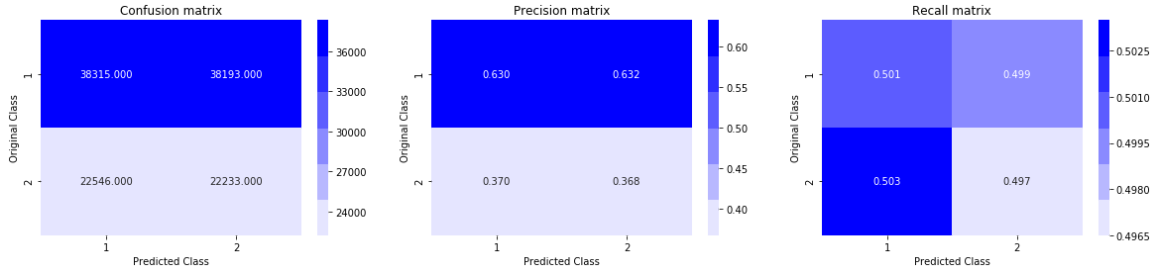
```
    plt.show()
```

Building a random model (Finding worst-case log-loss)

In [94]:

```
# we need to generate 9 numbers and the sum of numbers should be 1
# one solution is to genarate 9 numbers and divide each of the numbers by their sum
# ref: https://stackoverflow.com/a/18662466/4084039
# we create a output array that has exactly same size as the CV data

test_len = len(y_test)
predicted_y = np.zeros((test_len,2))
for i in range(test_len):
    rand_probs = np.random.rand(1,2)
    predicted_y[i] = ((rand_probs/sum(sum(rand_probs)))[0])
print("Log loss on Test Data using Random Model",log_loss(y_test, predicted_y, eps=1e-1
5))

predicted_y =np.argmax(predicted_y, axis=1)
plot_confusion_matrix(y_test, predicted_y)
```

```
Log loss on Test Data using Random Model 0.8904065495035155
```



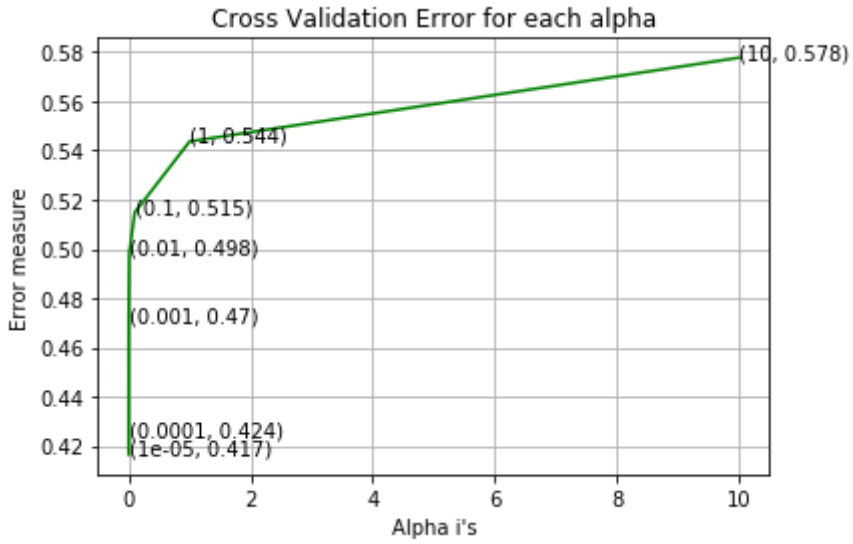
Logistic Regression Model.

In [95]:

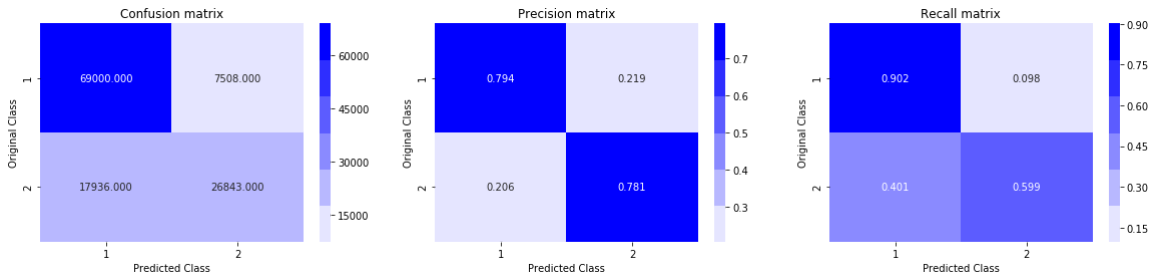
```
from tqdm import tqdm_notebook as tqdm

alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_iter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal', eta0=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, ...])     Fit linear model with Stochastic Gradient Descent.
# predict(X)    Predict class labels for samples in X.

#-------------------------------
# video link:
#-------------------------------


log_error_array=[]
for i in tqdm(alpha):
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=42)
    clf.fit(final_data_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(final_data_train, y_train)
    predict_y = sig_clf.predict_proba(final_data_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))

fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in tqdm(enumerate(np.round(log_error_array,3))):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l2', loss='log', random_state=42)
clf.fit(final_data_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(final_data_train, y_train)

predict_y = sig_clf.predict_proba(final_data_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(final_data_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
```

```
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.41650894648894
For values of alpha =  0.0001 The log loss is: 0.4242484952740375
For values of alpha =  0.001 The log loss is: 0.47048089305760604
For values of alpha =  0.01 The log loss is: 0.4982333828207982
For values of alpha =  0.1 The log loss is: 0.5148196423297065
For values of alpha =  1 The log loss is: 0.5436698742866424
For values of alpha =  10 The log loss is: 0.5776708988960267
```




```
For values of best alpha =  1e-05 The train log loss is: 0.380417554336459
74
For values of best alpha =  1e-05 The test log loss is: 0.41650894648894
Total number of data points : 121287
```



From above we get best value of alpha as 1e-05

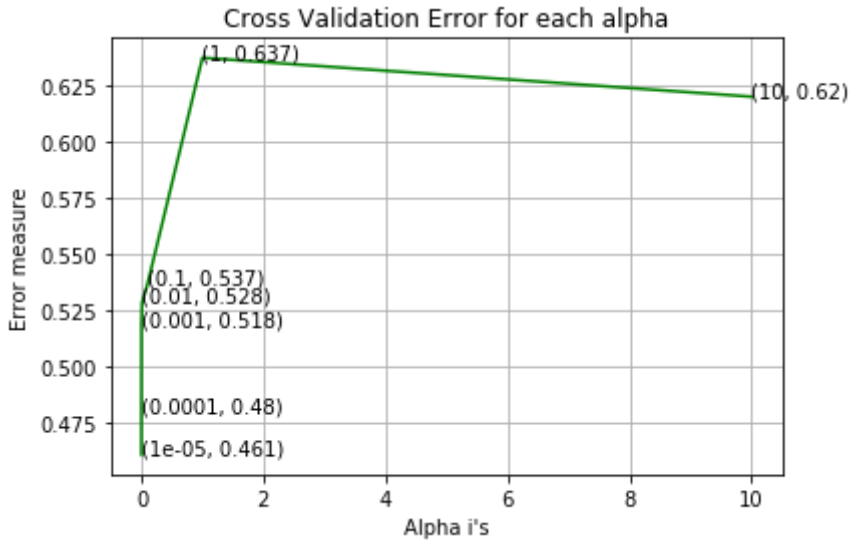
Trying Linear SVM model with hyperparameter tuning

In [96]:

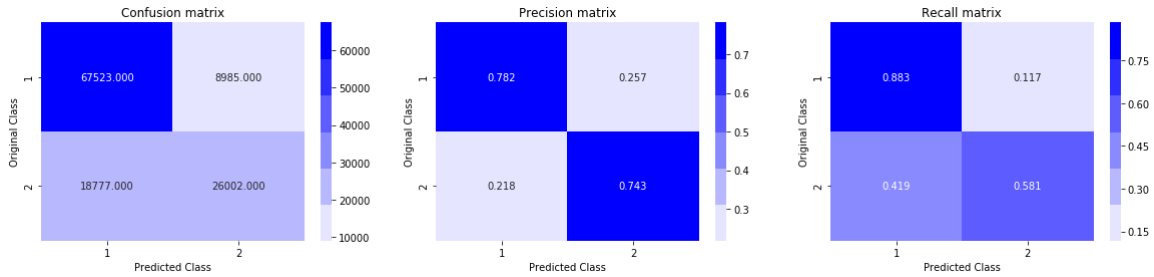
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

# read more about SGDClassifier() at http://scikit-learn.org/stable/modules/generated/sklearn.linear_model.SGDClassifier.html
# ------------------------------
# default parameters
# SGDClassifier(loss='hinge', penalty='l2', alpha=0.0001, l1_ratio=0.15, fit_intercept=True, max_iter=None, tol=None,
# shuffle=True, verbose=0, epsilon=0.1, n_jobs=1, random_state=None, learning_rate='optimal', eta0=0.0, power_t=0.5,
# class_weight=None, warm_start=False, average=False, n_iter=None)

# some of methods
# fit(X, y[, coef_init, intercept_init, ...])     Fit linear model with Stochastic Gradient Descent.
# predict(X)    Predict class labels for samples in X.

#-------------------------------
# video link:
#------------------------------


log_error_array=[]
for i in tqdm(alpha):
    clf = SGDClassifier(alpha=i, penalty='l1', loss='hinge', random_state=42)
    clf.fit(final_data_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(final_data_train, y_train)
    predict_y = sig_clf.predict_proba(final_data_test)
    log_error_array.append(log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))

fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in tqdm(enumerate(np.round(log_error_array,3))):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")
plt.show()


best_alpha = np.argmin(log_error_array)
clf = SGDClassifier(alpha=alpha[best_alpha], penalty='l1', loss='hinge', random_state=42)
clf.fit(final_data_train, y_train)
sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
sig_clf.fit(final_data_train, y_train)

predict_y = sig_clf.predict_proba(final_data_train)
print('For values of best alpha = ', alpha[best_alpha], "The train log loss is:",log_loss(y_train, predict_y, labels=clf.classes_, eps=1e-15))
predict_y = sig_clf.predict_proba(final_data_test)
print('For values of best alpha = ', alpha[best_alpha], "The test log loss is:",log_loss(y_test, predict_y, labels=clf.classes_, eps=1e-15))
predicted_y =np.argmax(predict_y,axis=1)
```

```
print("Total number of data points :", len(predicted_y))
plot_confusion_matrix(y_test, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.46093289260970616
For values of alpha =  0.0001 The log loss is: 0.47986626864038295
For values of alpha =  0.001 The log loss is: 0.518334186158981
For values of alpha =  0.01 The log loss is: 0.5284372478286475
For values of alpha =  0.1 The log loss is: 0.5366349139309585
For values of alpha =  1 The log loss is: 0.6370270642507664
For values of alpha =  10 The log loss is: 0.6197422676238169
```




```
For values of best alpha =  1e-05 The train log loss is: 0.429270957361263
97
For values of best alpha =  1e-05 The test log loss is: 0.4609328926097061
6
Total number of data points : 121287
```



From above we get best alpha as 1e-05

Hyperparameter tune Xg Boost using RandomSearch to reduce the log-loss by

Featurizing text data with tfidf weighted word-vectors

We will be using spacy

In [97]:

```
import pandas as pd
import matplotlib.pyplot as plt
import re
import time
import warnings
import numpy as np
from nltk.corpus import stopwords
from sklearn.preprocessing import normalize
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.feature_extraction.text import TfidfVectorizer
warnings.filterwarnings("ignore")
import sys
import os
import pandas as pd
import numpy as np
from tqdm import tqdm

# exctract word2vec vectors
# https://github.com/explosion/spaCy/issues/1721
# http://landinghub.visualstudio.com/visual-cpp-build-tools
import spacy
```

In [98]:

```
import en_core_web_sm
```

In [99]:

```
df_train_advanced
```

Out[99]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1l
0	307323	430984	430985	why have not more car companies used cvcc tech...	why have not more car companies used cvcc tech...	1	1	
1	34363	14381	62970	is it normal to fall out of love	how do i fall out of love with someone	5	6	
2	98028	87590	162974	cash how much usd can i legally carry on my p...	how much cash can you keep at home legally in ...	3	1	
3	251666	365834	365835	what were major contributions of the assyrian	what were the assyrians major contributions t...	1	1	
4	152166	239124	239125	what is the coolest scientific experiment on...	what is the coolest science experiment to do a...	2	1	
5	365918	496052	496053	how do i write a thesis paper	how can i write a strong thesis paper	1	1	
6	214664	93170	320316	will the big bang theory continue after season...	will season 10 of big bang theory be the final...	2	2	
7	213344	306991	66064	what does an average japanese think about china	what do japanese people think about china	2	3	
8	274006	392553	392554	how are servers connected to the internet	my internet explorer is unable to connect to t...	1	1	
9	313902	285631	438528	which myers briggs personality type was sigmun...	which myers briggs types are the messiest	1	1	
10	159675	249223	249224	aap has said that it is against corruption ho...	is the aap losing support in delhi	1	1	
11	49001	87255	87256	what was it like taking part in one of nickelo...	what is the number one nickelodeon show ever	1	1	
12	220173	327222	327223	who would win in a fight general grievous or d...	who would win darth maul vs general grievous	1	1	

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1l
13	293902	415700	415701	when hiking how do i carry a tent and a sleep...	how are sleeping bag temperatures rated	1	1	
14	332637	103810	15235	how do i overcome depression	what should i do to overcome depression	3	4	
15	49603	88265	88266	what is the unit of measuring phone battery st...	does keeping phone on 4g affects the battery	1	1	
16	234085	43358	72735	what are some mind blowing safe wallets 2016 t...	what are some mind blowing men wallets that ex...	5	2	
17	182481	279275	279276	is the following fact even possible in 1935 d...	the u s gets involved in most major conflicts...	1	1	1
18	66364	115038	115039	does income through sale on inherited property...	is it true that companies claim loss by piracy...	1	1	1
19	5446	10714	10715	what would happen if the color would disappear...	what would happen if color were to disappear f...	1	1	
20	218896	138177	69009	what is your opinion to finish p v sindhu own ...	what is your reaction towards p v sindhu own ...	2	2	
21	192226	291808	291809	why does volumetric strain volume of a solid b...	why does the volumetric strain volume of a sol...	1	1	1
22	48205	85989	63034	why is my underwear stained yellow	why do we wear underwear	1	6	
23	392539	18794	525243	if you read or ignore a message request on fac...	how do you know if someone has read your messa...	4	1	
24	155434	2304	243501	what is literally the most fastest way to make...	what is the best and fast way to make money	3	2	
25	11978	23112	16715	how much money can i make in a week playing po...	how much money can i make 5 days a week playin...	2	6	

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1l
26	399131	23547	383634	extraterrestrial life what is the most undeni...	what is the most convincing evidence for extra...	4	3	
27	301543	364607	424448	what should i eat to gain muscle fast	how much should i eat to gain muscle	3	1	
28	368483	62856	425017	does watching tv actually cause brain cells to...	is it true that using earphones cause damage t...	2	1	1
29	346065	474425	474426	what is the cheapest place to live in dc	what is the cheapest safest place to work and ...	1	1	
...	...	...	...	...	...	...	...	
282970	322506	448329	448330	what is the mass of the electron hole	what is the mass of an electron	1	1	
282971	403283	536848	536849	do the big stars ronaldo and messi typically...	if real madrid wins the champions league and b...	1	1	
282972	404022	3550	206616	can a family live comfortable on dollar 150k ...	can a family live on dollar 100k a year in ne...	1	6	
282973	143538	227403	227404	why does one vomit	why do we vomit	1	1	
282974	109301	179404	179405	what is the purpose of learning hindi language	which indian language other than hindi should ...	1	1	
282975	78069	133186	133187	what is it to be a genius	what does it take to be a genius	1	1	
282976	48553	86548	86549	did you get your marks corrected after the ree...	even after doing all the hard work i am not g...	1	1	
282977	331330	458211	458212	what is the best existing model for spatiotemp...	which sports are best known for data analysis	1	1	
282978	86333	145630	145631	which are the most common kannada phrases exp...	what is your favourite kannada word phrase why	1	1	

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1l
282979	348795	477383	477384	do you think there is still stigma around page...	you had an article about an israeli company th...	1	1	
282980	89963	151049	151050	how were you bullied for being lgbt	how have people bullied you for being lgbtqiapk	1	1	
282981	18175	34450	34451	what is the best way to flush methamphetamines...	medicine and healthcare what is the best way ...	4	2	
282982	61387	107187	107188	what would happen if a nuclear weapon were det...	what would happen if we nuked the moon	3	1	
282983	318482	443852	443853	how do you create an api ready application usi...	does using a framework such as codeigniter cau...	1	1	
282984	229802	339194	339195	why does it take so long for some gas station ...	a single 18 wheeler with a gas tank seems smal...	1	1	
282985	325938	283162	452196	i have a r b1 b2 us visa for 10 years can i ...	i was visiting the us on a b1 b2 visa valid fo...	1	1	1
282986	97665	162465	162466	is thank you for letting me know correct wh...	is this sentence correct let me know of the r...	2	1	
282987	340286	467993	467994	how would you use to modify a string buffer to...	how do you convert an enum to a string	1	1	
282988	172080	265796	265797	pos for car washes business	is the new rbi governor is just a mere puppet...	1	1	
282989	250865	364858	364859	is prodapt a good company	what is a good company	1	1	
282990	91355	153105	153106	what is considered as a necessity under sectio...	i have done b tech but english interest me wh...	1	1	
282991	147930	27003	42620	what is an easy way to commit suicide	what is a sure way to commit suicide	5	11	

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1l
282992	330062	119381	31362	how do i prepare comprehensively for the ugc n...	how do i prepare for ugc net english literatur...	8	5	
282993	60435	105685	105686	how do i go about creating a device and an app...	is there a child like trait always alive somew...	1	1	
282994	179113	274926	274927	is the yellow tag on peoples profiles on skype...	why does not donald trump wear open shirts is...	1	1	
282995	129909	208581	208582	what do obama do	what will obama do next	1	1	
282996	102514	169599	169600	my mother is a family pensioner and i am worki...	i belong to obc non creamy layer while fillin...	3	1	1
282997	81823	138863	138864	how do i reduce the speed of dc motor by keepi...	why does power factor lower as motor load is r...	1	1	
282998	284906	6892	4628	which is the best way to control anger	what is the best method to control anger	5	10	
282999	25108	46820	46821	how do you think about chinese food	what do you think of the chinese food	2	2	

283000 rows × 31 columns

In [100]:

```
df_train_advanced.head()
```

Out[100]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1
0	307323	430984	430985	why have not more car companies used cvcc tech...	why have not more car companies used cvcc tech...	1	1	66	52	
1	34363	14381	62970	is it normal to fall out of love	how do i fall out of love with someone	5	6	33	39	
2	98028	87590	162974	cash how much usd can i legally carry on my p...	how much cash can you keep at home legally in ...	3	1	91	52	
3	251666	365834	365835	what were major contributions of the assyrian	what were the assyrians major contributions t...	1	1	46	61	
4	152166	239124	239125	what is the coolest scientific experiment on...	what is the coolest science experiment to do a...	2	1	70	53	

5 rows × 31 columns

In [101]:

```
df_test_advanced.head()
```

Out[101]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1_n_
0	175087	176590	269669	what are numbers do numbers exist where are ...	what are numbers do numbers exist	1	1	91	35	
1	347894	476403	476404	how is victoria beckham involved with victoria...	why are victoria secret models so old in comp...	1	1	56	77	
2	152745	239913	239914	how genuine were the business leaders and cele...	anyone has an idea about samsung j5570 tv mode...	1	1	112	136	
3	205968	96410	44271	what kinds of thing can young people learn fro...	what could young people learn from old people	2	3	59	46	
4	60393	105617	90554	where can i get real active instagram followers	what is the best way to get real instagram fol...	2	3	48	53	

5 rows × 31 columns

In [109]:

```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.feature_extraction.text import CountVectorizer
# merge texts
questions_train = list(df_train_advanced['question1']) + list(df_train_advanced['questi
on2'])

tfidf_train = TfidfVectorizer(lowercase=False,)
tfidf_train.fit_transform(questions_train)


# dict key:word and value:tf-idf score
word_to_tfidf_train = dict(zip(tfidf_train.get_feature_names(), tfidf_train.idf_))
```

In [110]:

```
#print(word_to_tfidf_train)

print(len(word_to_tfidf_train))
```

```
75241
```

In [111]:

```
questions_test = list(df_test_advanced['question1']) + list(df_test_advanced['question
2'])

tfidf_train.fit_transform(questions_test)

word_to_tfidf_test = dict(zip(tfidf_train.get_feature_names(), tfidf_train.idf_))
```

In [113]:

```
print(len(word_to_tfidf_test))
```

```
51253
```

- After we find TF-IDF scores, we convert each question to a weighted average of word2vec vectors by these scores.
- here we use a pre-trained GLOVE model which comes free with "Spacy". https://spacy.io/usage/vectors-similarity (https://spacy.io/usage/vectors-similarity)
- It is trained on Wikipedia and therefore, it is stronger in terms of word semantics.

Training data

In [118]:

```
nlp = en_core_web_sm.load()
b = nlp("  why is windows 8 1 better than windows 8")
print(b[0])
print(b[0].vector)
print(len(b[1].vector))
```

```
[-0.9525662  -2.5002687  -4.4875417  -1.9638036  -1.6534147  -0.73024225
  4.281701    2.6608083  -0.9626423   3.2770376   3.1853538   0.14069447
 -1.450932   -4.0068707  -1.8085659   1.0211391   2.7586927   0.1162557
 -1.6390661   1.3143853  -0.8224641  -1.1862966  -2.4527912   7.3386655
 -1.9965899   0.27951044 -1.9422514  -3.2176871   4.68439     9.470723
  3.9927957  -1.8580525  -2.2689922  -0.39820725 -0.32314092  0.24061304
  1.1145824   1.3387492   0.07262322 -0.03293261 -0.39051062 -0.21403557
 -2.4694285   1.2359965  -0.74682236 -3.722413    1.0628393   0.05004019
 -0.38331282 -0.8995835  -4.4561625   0.3103042  -1.8295093  -4.13437
  0.99405587  0.6113877  -0.55875224  1.5417417  -5.6916676   1.1636375
 -0.76107544  0.03636897 -0.0314011   0.84815174 -0.7989348   0.20037794
  3.8253684  -4.6280785  -2.6242979  -0.88505507  0.9127014   0.4201569
  0.9240186   3.270088    0.3128389  -1.1580241  -1.5440085  -1.7788529
  4.42894    -3.5577254   0.43271866  1.8254749  -3.9023294   2.0697098
  0.77257717  3.1848168   1.1968281   3.5901434   1.4834808  -0.945392
  2.0864286   0.9572348  -5.3374486   1.268468    1.9111385   3.8454902 ]
96
```

In [113]:

```
for i in list(df_train_advanced['question1'][13225:13235]):
    print(i)
    print(type(i))
```

```
which are some of the best pictures that make us proud as indians
<class 'str'>
how much is the living cost in jakarta  indonesia
<class 'str'>
how do you delete a question on quora
<class 'str'>
why nobody answer my questions in quora
<class 'str'>
is it easy to learn java
<class 'str'>
why is windows 8 1 better than windows 8
<class 'str'>
how can i get an internship in a paris museum
<class 'str'>
what online payment methods are most popular in yemen
<class 'str'>
how do i get employed with quora
<class 'str'>
are we being slaves to money
<class 'str'>
```

In [150]:

```
df_train_advanced['question1'][12514:12518]
```

Out[150]:

```
12514                            which are the best novel
12515    which are the best countries for civil enginee...
12516    what is the reaction between copper nitrate an...
12517    do men always initiate conversation if they li...
Name: question1, dtype: object
```

In [148]:

```
type(list(df_train_advanced['question1'][12514:12518]))
```

Out[148]:

```
list
```

In [205]:

```
# question 1 column train data

from tqdm import tqdm_notebook as tqdm
# en_vectors_web_lg, which includes over 1 million unique vectors.
#nlp = spacy.load('en_core_web_sm')

nlp = en_core_web_sm.load()

vecs1 = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu1 in tqdm(list(df_train_advanced['question1'])):
    doc1 = nlp(qu1)
    # 384 is the number of dimensions of vectors
    if len(doc1) == 0:
        mean_vec1 = np.zeros([1, len(nlp(" ").vector)])
    else:
        mean_vec1 = np.zeros([len(doc1), len(doc1[0].vector)])
    for word1 in doc1:
        # word2vec
        vec1 = word1.vector
        # fetch df score
        try:
            idf = word_to_tfidf_train[str(word1)]
        except:
            idf = 0
        # compute final vec
        mean_vec1 += vec1 * idf
    mean_vec1 = mean_vec1.mean(axis=0)
    vecs1.append(mean_vec1)
df_train_advanced['q1_feats_m'] = list(vecs1)
```

In [ ]:

```

```

In [208]:

```
# question 2 column train data

vecs2 = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu2 in tqdm(list(df_train_advanced['question2'])):
    doc1 = nlp(qu2)
    # 384 is the number of dimensions of vectors
    if len(doc1) == 0:
        mean_vec2 = np.zeros([1, len(nlp(" ").vector)])
    else:
        mean_vec2 = np.zeros([len(doc1), len(doc1[0].vector)])
    for word1 in doc1:
        # word2vec
        vec2 = word1.vector
        # fetch df score
        try:
            idf = word_to_tfidf_train[str(word1)]
        except:
            idf = 0
        # compute final vec
        mean_vec2 += vec2 * idf
    mean_vec2 = mean_vec2.mean(axis=0)
    vecs2.append(mean_vec2)
df_train_advanced['q2_feats_m'] = list(vecs2)
```

In [209]:

```
# question 1 column test data


from tqdm import tqdm_notebook as tqdm
# en_vectors_web_lg, which includes over 1 million unique vectors.
#nlp = spacy.load('en_core_web_sm')

nlp = en_core_web_sm.load()

vecs3 = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu1 in tqdm(list(df_test_advanced['question1'])):
    doc1 = nlp(qu1)
    # 384 is the number of dimensions of vectors
    if len(doc1) == 0:
        mean_vec3 = np.zeros([1, len(nlp(" ").vector)])
    else:
        mean_vec3 = np.zeros([len(doc1), len(doc1[0].vector)])
    for word1 in doc1:
        # word2vec
        vec3 = word1.vector
        # fetch df score
        try:
            idf = word_to_tfidf_train[str(word1)]
        except:
            idf = 0
        # compute final vec
        mean_vec3 += vec3 * idf
    mean_vec3 = mean_vec3.mean(axis=0)
    vecs3.append(mean_vec3)
df_test_advanced['q1_feats_m'] = list(vecs3)
```

In [210]:

```
# question 2 column test data


from tqdm import tqdm_notebook as tqdm
# en_vectors_web_lg, which includes over 1 million unique vectors.
#nlp = spacy.load('en_core_web_sm')

nlp = en_core_web_sm.load()

vecs4 = []
# https://github.com/noamraph/tqdm
# tqdm is used to print the progress bar
for qu1 in tqdm(list(df_test_advanced['question2'])):
    doc1 = nlp(qu1)
    # 384 is the number of dimensions of vectors
    if len(doc1) == 0:
        mean_vec4 = np.zeros([1, len(nlp(" ").vector)])
    else:
        mean_vec4 = np.zeros([len(doc1), len(doc1[0].vector)])
    for word1 in doc1:
        # word2vec
        vec4 = word1.vector
        # fetch df score
        try:
            idf = word_to_tfidf_train[str(word1)]
        except:
            idf = 0
        # compute final vec
        mean_vec4 += vec4 * idf
    mean_vec4 = mean_vec4.mean(axis=0)
    vecs4.append(mean_vec4)
df_test_advanced['q2_feats_m'] = list(vecs4)
```

In [211]:

```
df_test_advanced.shape
```

Out[211]:

```
(121287, 33)
```

In [212]:

```
df_train_advanced.shape
```

Out[212]:

```
(283000, 33)
```

In [213]:

```
len(df_test_advanced["q2_feats_m"])
```

Out[213]:

```
121287
```

In [214]:

```
len(df_test_advanced["q1_feats_m"])
```

Out[214]:

```
121287
```

In [215]:

```
len(df_train_advanced["q2_feats_m"])
```

Out[215]:

```
283000
```

In [216]:

```
len(df_train_advanced["q1_feats_m"])
```

Out[216]:

```
283000
```

In [217]:

```
df_train_advanced.columns
```

Out[217]:

```
Index(['id', 'qid1', 'qid2', 'question1', 'question2', 'freq_qid1',
       'freq_qid2', 'q1len', 'q2len', 'q1_n_words', 'q2_n_words',
       'word_Common', 'word_Total', 'word_share', 'freq_q1+q2', 'freq_q1-q
2',
       'cwc_min', 'cwc_max', 'csc_min', 'csc_max', 'ctc_min', 'ctc_max',
       'last_word_eq', 'first_word_eq', 'abs_len_diff', 'mean_len',
       'token_set_ratio', 'token_sort_ratio', 'fuzz_ratio',
       'fuzz_partial_ratio', 'longest_substr_ratio', 'q1_feats_m',
       'q2_feats_m'],
      dtype='object')
```

In [218]:

```
len(df_train_advanced["q1_feats_m"][5])
```

Out[218]:

```
96
```

In [219]:

```
len(df_test_advanced["q2_feats_m"][50])
```

Out[219]:

```
96
```

In [220]:

```
df_train_advanced.head(2)
```

Out[220]:

	id	qid1	qid2	question1	question2	freq_qid1	freq_qid2	q1len	q2len	q1_n_
0	307323	430984	430985	why have not more car companies used cvcc tech...	why have not more car companies used cvcc tech...	1	1	66	52	
1	34363	14381	62970	is it normal to fall out of love	how do i fall out of love with someone	5	6	33	39	

2 rows × 33 columns

In [223]:

```
i = 5
b = "x" + str(i)
print(b)
```

```
x5
```

Now we need to convert the values in the q1_feats_m and q2_feats_m in the form of features and then our model will be ready

Every q2_feats_m and q1_feats_m value is a vector of 96 dimensions hence we will need 96 column names firstly hence lets create the column names first.

In [227]:

```
question_1_column_names = []
question_2_column_names = []

for i in range(0,96):
    question_1_column_names.append("que1_" + str(i))
    question_2_column_names.append("que2_" + str(i))

print(question_1_column_names)

print(question_2_column_names)
```

```
['que1_0', 'que1_1', 'que1_2', 'que1_3', 'que1_4', 'que1_5', 'que1_6', 'qu
e1_7', 'que1_8', 'que1_9', 'que1_10', 'que1_11', 'que1_12', 'que1_13', 'qu
e1_14', 'que1_15', 'que1_16', 'que1_17', 'que1_18', 'que1_19', 'que1_20',
'que1_21', 'que1_22', 'que1_23', 'que1_24', 'que1_25', 'que1_26', 'que1_2
7', 'que1_28', 'que1_29', 'que1_30', 'que1_31', 'que1_32', 'que1_33', 'que
1_34', 'que1_35', 'que1_36', 'que1_37', 'que1_38', 'que1_39', 'que1_40',
'que1_41', 'que1_42', 'que1_43', 'que1_44', 'que1_45', 'que1_46', 'que1_4
7', 'que1_48', 'que1_49', 'que1_50', 'que1_51', 'que1_52', 'que1_53', 'que
1_54', 'que1_55', 'que1_56', 'que1_57', 'que1_58', 'que1_59', 'que1_60',
'que1_61', 'que1_62', 'que1_63', 'que1_64', 'que1_65', 'que1_66', 'que1_6
7', 'que1_68', 'que1_69', 'que1_70', 'que1_71', 'que1_72', 'que1_73', 'que
1_74', 'que1_75', 'que1_76', 'que1_77', 'que1_78', 'que1_79', 'que1_80',
'que1_81', 'que1_82', 'que1_83', 'que1_84', 'que1_85', 'que1_86', 'que1_8
7', 'que1_88', 'que1_89', 'que1_90', 'que1_91', 'que1_92', 'que1_93', 'que
1_94', 'que1_95']
['que2_0', 'que2_1', 'que2_2', 'que2_3', 'que2_4', 'que2_5', 'que2_6', 'qu
e2_7', 'que2_8', 'que2_9', 'que2_10', 'que2_11', 'que2_12', 'que2_13', 'qu
e2_14', 'que2_15', 'que2_16', 'que2_17', 'que2_18', 'que2_19', 'que2_20',
'que2_21', 'que2_22', 'que2_23', 'que2_24', 'que2_25', 'que2_26', 'que2_2
7', 'que2_28', 'que2_29', 'que2_30', 'que2_31', 'que2_32', 'que2_33', 'que
2_34', 'que2_35', 'que2_36', 'que2_37', 'que2_38', 'que2_39', 'que2_40',
'que2_41', 'que2_42', 'que2_43', 'que2_44', 'que2_45', 'que2_46', 'que2_4
7', 'que2_48', 'que2_49', 'que2_50', 'que2_51', 'que2_52', 'que2_53', 'que
2_54', 'que2_55', 'que2_56', 'que2_57', 'que2_58', 'que2_59', 'que2_60',
'que2_61', 'que2_62', 'que2_63', 'que2_64', 'que2_65', 'que2_66', 'que2_6
7', 'que2_68', 'que2_69', 'que2_70', 'que2_71', 'que2_72', 'que2_73', 'que
2_74', 'que2_75', 'que2_76', 'que2_77', 'que2_78', 'que2_79', 'que2_80',
'que2_81', 'que2_82', 'que2_83', 'que2_84', 'que2_85', 'que2_86', 'que2_8
7', 'que2_88', 'que2_89', 'que2_90', 'que2_91', 'que2_92', 'que2_93', 'que
2_94', 'que2_95']
```

In [225]:

```
# now let us get the values of q1_feats_m and q2_feats_m out from their columns
# refer --> https://pandas.pydata.org/pandas-docs/stable/reference/api/pandas.DataFram
e.html

que1_values_train = pd.DataFrame(df_train_advanced.q1_feats_m.values.tolist(), index= d
f_train_advanced.index)

que2_values_train = pd.DataFrame(df_train_advanced.q2_feats_m.values.tolist(), index= d
f_train_advanced.index)

que1_values_test = pd.DataFrame(df_test_advanced.q1_feats_m.values.tolist(), index= df_
test_advanced.index)

que2_values_test = pd.DataFrame(df_test_advanced.q2_feats_m.values.tolist(), index= df_
test_advanced.index)
```

In [228]:

```
# let us give the column names for the new dataframe to be formed

# refer ---> https://datascience.stackexchange.com/questions/45314/dataframe-has-no-col
umn-names-how-to-add-a-header

que1_values_train.columns = question_1_column_names

que2_values_train.columns = question_2_column_names

que1_values_test.columns = question_1_column_names

que2_values_test.columns = question_2_column_names
```

In [229]:

```
# now let us merge the training dataframes first created above

data_training  = que1_values_train.join(que2_values_train,how ='outer')

data_testing = que1_values_test.join(que2_values_test,how="outer")
```

In [231]:

```
data_training.shape
```

Out[231]:

```
(283000, 192)
```

In [232]:

```
data_testing.shape
```

Out[232]:

```
(121287, 192)
```

Now as our data is ready let us apply XGBOOST implementation of GBDT on it along with hyperparameters using GridSearch and then finding the best values of hyperparameters.

In [234]:

```
import xgboost as xgb
clf_xgb = xgb.XGBClassifier(objective= 'binary:logistic',eval_metric='logloss')

# refer ---> https://scikit-learn.org/stable/modules/generated/sklearn.model_selection.
RandomizedSearchCV.html

tuned_parameters = {'max_depth' : [2,4,5,7],'n_estimators' : [100,250,400,550,700,800],
'learning_rate' : [0.001,0.1,1]}


grid_classifier = GridSearchCV(clf_xgb, tuned_parameters,verbose = 10,n_jobs=-1, cv=2,s
coring='neg_log_loss')


grid_classifier.fit(data_training,y_train)


best_params = grid_classifier.best_params_
best_value =  grid_classifier.best_score_

print("Best score received = ", best_value,"  ","best parameters were " , best_params)
```

```
Fitting 2 folds for each of 72 candidates, totalling 144 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 6 concurrent worker
s.
[Parallel(n_jobs=-1)]: Done   1 tasks      | elapsed:  3.7min
[Parallel(n_jobs=-1)]: Done   6 tasks      | elapsed: 11.2min
[Parallel(n_jobs=-1)]: Done  13 tasks      | elapsed: 38.5min
[Parallel(n_jobs=-1)]: Done  20 tasks      | elapsed: 68.3min
[Parallel(n_jobs=-1)]: Done  29 tasks      | elapsed: 102.0min
[Parallel(n_jobs=-1)]: Done  38 tasks      | elapsed: 150.3min
[Parallel(n_jobs=-1)]: Done  49 tasks      | elapsed: 210.3min
[Parallel(n_jobs=-1)]: Done  60 tasks      | elapsed: 239.5min
[Parallel(n_jobs=-1)]: Done  73 tasks      | elapsed: 293.3min
[Parallel(n_jobs=-1)]: Done  86 tasks      | elapsed: 358.2min
[Parallel(n_jobs=-1)]: Done 101 tasks      | elapsed: 433.5min
[Parallel(n_jobs=-1)]: Done 116 tasks      | elapsed: 481.8min
[Parallel(n_jobs=-1)]: Done 133 tasks      | elapsed: 566.2min
[Parallel(n_jobs=-1)]: Done 144 out of 144 | elapsed: 647.6min finished

Best score received =  -0.4651896535321332    best parameters were  {'lear
ning_rate': 0.1, 'max_depth': 7, 'n_estimators': 800}
```

Now from above we have received the value of best parameters hence let's apply XGBoost using the best parameters

In [235]:

```
import xgboost as xgb
params = {}
params['objective'] = 'binary:logistic'
params['eval_metric'] = 'logloss'
params['eta'] = 0.1
params['max_depth'] = 7
params['n_estimators'] = 800

d_train = xgb.DMatrix(data_training, label=y_train)
d_test = xgb.DMatrix(data_testing, label=y_test)

watchlist = [(d_train, 'train'), (d_test, 'valid')]

bst = xgb.train(params, d_train, 400, watchlist, early_stopping_rounds=20, verbose_eval
=10)

xgdmat = xgb.DMatrix(data_training,y_train)
predict_y = bst.predict(d_test)
print("The test log loss is:",log_loss(y_test, predict_y,eps=1e-15))
```

```
[0]     train-logloss:0.677234  valid-logloss:0.678349
Multiple eval metrics have been passed: 'valid-logloss' will be used for e
arly stopping.

Will train until valid-logloss hasn't improved in 20 rounds.
[10]    train-logloss:0.601503  valid-logloss:0.609432
[20]    train-logloss:0.574238  valid-logloss:0.586508
[30]    train-logloss:0.55653   valid-logloss:0.572627
[40]    train-logloss:0.543201  valid-logloss:0.562906
[50]    train-logloss:0.53299   valid-logloss:0.555764
[60]    train-logloss:0.523262  valid-logloss:0.549455
[70]    train-logloss:0.515069  valid-logloss:0.544095
[80]    train-logloss:0.508041  valid-logloss:0.539736
[90]    train-logloss:0.501764  valid-logloss:0.536033
[100]   train-logloss:0.495252  valid-logloss:0.532235
[110]   train-logloss:0.488166  valid-logloss:0.528385
[120]   train-logloss:0.482994  valid-logloss:0.525676
[130]   train-logloss:0.477306  valid-logloss:0.522619
[140]   train-logloss:0.472524  valid-logloss:0.520162
[150]   train-logloss:0.46797   valid-logloss:0.517961
[160]   train-logloss:0.462941  valid-logloss:0.515616
[170]   train-logloss:0.458747  valid-logloss:0.513456
[180]   train-logloss:0.454194  valid-logloss:0.511251
[190]   train-logloss:0.449591  valid-logloss:0.509012
[200]   train-logloss:0.44506   valid-logloss:0.507002
[210]   train-logloss:0.440743  valid-logloss:0.505049
[220]   train-logloss:0.436925  valid-logloss:0.503422
[230]   train-logloss:0.433088  valid-logloss:0.501882
[240]   train-logloss:0.429069  valid-logloss:0.500182
[250]   train-logloss:0.426415  valid-logloss:0.499081
[260]   train-logloss:0.423793  valid-logloss:0.497998
[270]   train-logloss:0.419526  valid-logloss:0.496122
[280]   train-logloss:0.415372  valid-logloss:0.494496
[290]   train-logloss:0.411595  valid-logloss:0.492926
[300]   train-logloss:0.407347  valid-logloss:0.491229
[310]   train-logloss:0.404627  valid-logloss:0.490345
[320]   train-logloss:0.401045  valid-logloss:0.488903
[330]   train-logloss:0.398583  valid-logloss:0.488075
[340]   train-logloss:0.39582   valid-logloss:0.487079
[350]   train-logloss:0.393198  valid-logloss:0.486276
[360]   train-logloss:0.389352  valid-logloss:0.48469
[370]   train-logloss:0.386752  valid-logloss:0.483754
[380]   train-logloss:0.384091  valid-logloss:0.482803
[390]   train-logloss:0.380744  valid-logloss:0.481423
[399]   train-logloss:0.378051  valid-logloss:0.480392
The test log loss is: 0.48039193353469456
```

Conclusions and Summary

In [236]:

```
from prettytable import PrettyTable

x = PrettyTable(["Model", "Vectorizer" ,"Hyperparameter Tuning","Train-logloss", "Test-log loss"])

x.add_row(["Logistic Regression" ,"TD_IDF ","yes", 0.38041755, 0.4165089])

x.add_row(["Linear SVM" ,"TD_IDF ","yes", 0.4292709, 0.4292709])

x.add_row(["XG Boost implementation of GBDT" ,"TD_IDF Weighted W2V ","yes", 0.3780, 0.4803919])

print(x)
```

```
+---------------------------------+----------------------+---------------
-------+---------------+---------------+
|              Model              |      Vectorizer      | Hyperparameter
Tuning | Train-logloss | Test-log loss |
+---------------------------------+----------------------+---------------
-------+---------------+---------------+
|       Logistic Regression       |       TD_IDF         |          yes
|   0.38041755  |   0.4165089   |
|            Linear SVM           |       TD_IDF         |          yes
|   0.4292709   |   0.4292709   |
| XG Boost implementation of GBDT | TD_IDF Weighted W2V  |          yes
|     0.378     |   0.4803919   |
+---------------------------------+----------------------+---------------
-------+---------------+---------------+
```

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