In [0]:

```
from google.colab import drive
drive.mount('/content/MyDrive/')
```

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6
qk8qdgf4n4g3pfee6491hc0brc4i.apps.googleusercontent.com&redirect_uri=urn%3aietf%3awg%3aoauth%3a2.0%
b&response_type=code&scope=email%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdocs.test%20https%3a%2
www.googleapis.com%2fauth%2fdrive%20https%3a%2f%2fwww.googleapis.com%2fauth%2fdrive.photos.readonly
ttps%3a%2f%2fwww.googleapis.com%2fauth%2fpeopleapi.readonly

Enter your authorization code:
··········
Mounted at /content/MyDrive/
```

In [2]:

```
import nltk
nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to /home/ubuntu/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Out[2]:

```
True
```

In [3]:

```
#import liraries
#General
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
import os
import warnings
warnings.filterwarnings('ignore')

#others
import plotly.offline as py
py.init_notebook_mode(connected=True)
import plotly.graph_objs as go
import plotly.tools as tls
from tqdm import tqdm
import sqlite3
from sqlalchemy import create_engine
import datetime

#preprocessing
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from bs4 import BeautifulSoup
import distance
from wordcloud import WordCloud
from sklearn.preprocessing import MinMaxScaler
from sklearn.manifold import TSNE
import cv2
import spacy
from sklearn.feature_extraction.text import TfidfVectorizer

#Modelling
from sklearn.model_selection import train_test_split
from sklearn.linear_model import SGDClassifier
from sklearn.calibration import CalibratedClassifierCV
from xgboost import XGBClassifier
from sklearn.metrics import log_loss
from sklearn.model_selection import GridSearchCV
from sklearn.dummy import DummyClassifier
from sklearn.metrics import confusion_matrix
```

```
from sklearn.metrics import confusion_matrix
```

1. Reading Data

In [0]:

```
df = pd.read_csv('/content/MyDrive/My Drive/Applied AI/Case studies/1. Quora/train.csv')
df.head()
```

Out[0]:

	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 [0]:

```
print(df.shape)
```

```
(404290, 6)
```

In [0]:

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 404290 entries, 0 to 404289
Data columns (total 6 columns):
 #   Column        Non-Null Count   Dtype 
---  ------        --------------   ----- 
 0   id            404290 non-null  int64 
 1   qid1          404290 non-null  int64 
 2   qid2          404290 non-null  int64 
 3   question1     404289 non-null  object
 4   question2     404288 non-null  object
 5   is_duplicate  404290 non-null  int64 
dtypes: int64(4), object(2)
memory usage: 18.5+ MB
```

In [0]:

```
df.isna().sum()
```

Out[0]:

```
id              0
qid1            0
qid2            0
question1       1
question2       2
is_duplicate    0
dtype: int64
```

2.EDA

2.1 Distribution of data points based on output variable

In [0]:

```
df.groupby('is_duplicate')['id'].count()
```

Out[0]:

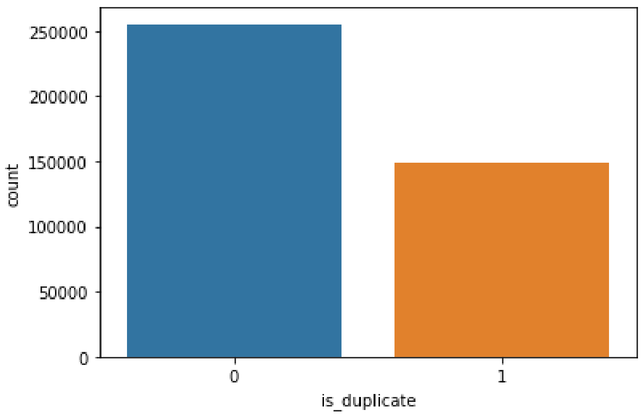
```
is_duplicate
0    255027
1    149263
Name: id, dtype: int64
```

In [0]:

```
sns.countplot(x='is_duplicate', data =df)
```

Out[0]:

```
&lt;matplotlib.axes._subplots.AxesSubplot at 0x7f362cbb9898&gt;
```



2.2 Percentage of points where is_duplicate = 0 & 1

In [0]:

```
print(len(df[df['is_duplicate']==0]))
print(len(df[df['is_duplicate']==1]))
print(len(df[df['is_duplicate']==0]) + len(df[df['is_duplicate']==1]))
print(len(df))
```

```
255027
149263
404290
404290
```

In [0]:

```
print('Percentage of points where is_duplicate=0:',((len(df[df['is_duplicate']==0]))/ (len(df)))*10
0)
print('Percentage of points where is_duplicate=1:', ((len(df[df['is_duplicate']==1]))/(len(df)))*10
0)
```

```
Percentage of points where is_duplicate=0: 63.08021469737069
Percentage of points where is_duplicate=1: 36.9197853026293
```

2.3 Number of Unique question in dataset

In [0]:

```
#take qids on both questions and combine them and use 'set' to find unique qids
print('Total number of unique questions:', len(list(set(df['qid1'].tolist() + df['qid2'].tolist()))
)
```

Out[0]:

```
537933
```

In [0]:

```
#unique qids that appear max than one time
print(pd.Series(df['qid1'].tolist() + df['qid2'].tolist()).value_counts())
print('Number of times a qid appears most:',max(pd.Series(df['qid1'].tolist() + df['qid2'].tolist()
).value_counts()))
```

```
2559      157
30782     120
4044      111
2561       88
14376      79
         ...
75109       1
81254       1
85352       1
83305       1
168274      1
Length: 537933, dtype: int64
Number of times a qid appears most: 157
```

In [0]:

```
print((pd.Series([1,2,3,3,4,4,5,6])).value_counts() > 1)
#to add number of True we use sum
print(sum((pd.Series([1,2,3,3,4,4,5,6])).value_counts() > 1))
```

```
4     True
3     True
6    False
5    False
2    False
1    False
dtype: bool
2
```

In [0]:

```
#number of unique qids that appear more than one time
sum(pd.Series(df['qid1'].tolist() + df['qid2'].tolist()).value_counts() > 1)
```

Out[0]:

```
111780
```

2.4 Count plot for unique questions and repeated question

In [0]:

```
total_qids = len(df['qid1'].tolist() + df['qid2'].tolist())
no_unique_qids = len(list(set(df['qid1'].tolist() + df['qid2'].tolist())))
repeated_qids = total_qids - no_unique_qids

print(no_unique_qids)
print(repeated_qids)
```

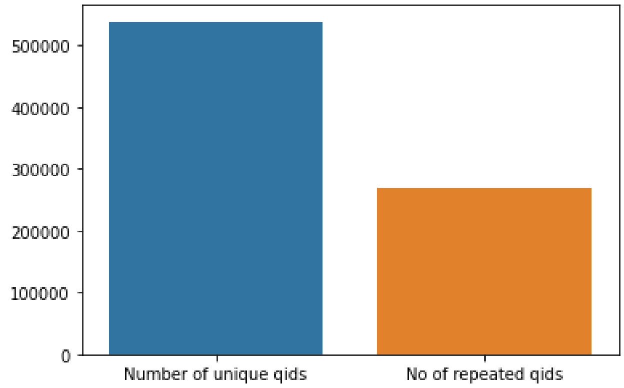
```
537933
270647
```

In [0]:

```
x =['Number of unique qids', 'No of repeated qids']
y = [no_unique_qids, repeated_qids]
sns.barplot(x,y)
```

Out[0]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f362c9d3128>
```



2.5 Checking for Duplicates

In [0]:

```
pair_dupicates = df[['qid1', 'qid2', 'is_duplicate']].groupby(['qid1', 'qid2']).count().reset_index
()
pair_dupicates
```

Out[0]:

	qid1	qid2	is_duplicate
0	1	2	1
1	3	4	1
2	3	282170	1
3	3	380197	1
4	3	488853	1
...	...	...	...
404285	537924	537925	1
404286	537926	537927	1
404287	537928	537929	1
404288	537930	537931	1
404289	537932	537933	1

404290 rows × 3 columns

In [0]:

```
print('No of duplicates=', df.shape[0] - pair_dupicates.shape[0])
```

```
No of duplicates= 0
```

2.6 Number of occurences of each question

In [0]:

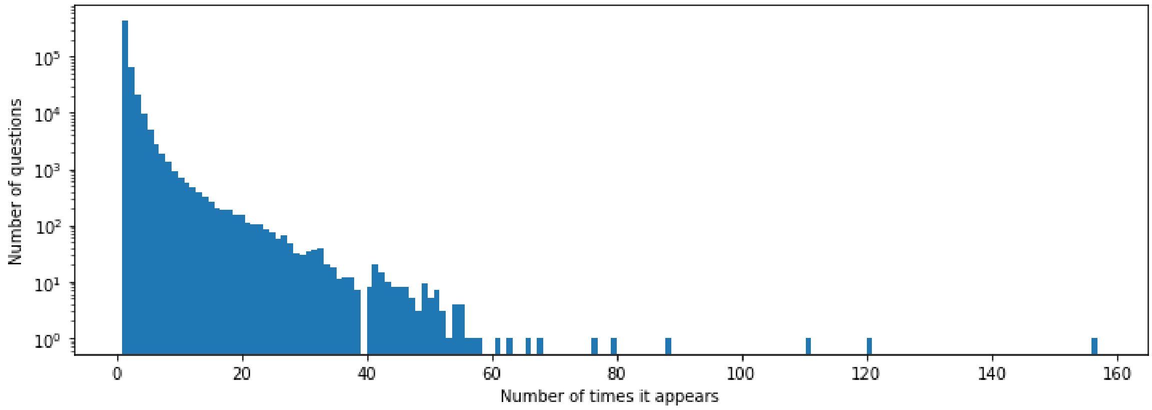
```
number_of_occurences_of_each_qids = pd.Series(df['qid1'].tolist()+df['qid2'].tolist()).value_counts
()
print(number_of_occurences_of_each_qids)
```

```
2559      157
30782     120
4044      111
```

```
2561        88
14376       79
          ...
75109        1
81254        1
85352        1
83305        1
168274       1
Length: 537933, dtype: int64
```

In [0]:

```
plt.figure(figsize=(12,4))
plt.hist(number_of_occurences_of_each_qids, bins=160)
plt.yscale('log')
plt.ylabel('Number of questions')
plt.xlabel('Number of times it appears')
plt.show()
```



2.7 Checking for Null values

In [0]:

```
df.isna().sum()
```

Out[0]:

```
id              0
qid1            0
qid2            0
question1       1
question2       2
is_duplicate    0
dtype: int64
```

In [0]:

```
df[df.isna().any(1)]
```

Out[0]:

	id	qid1	qid2	question1	question2	is_duplicate
105780	105780	174363	174364	How can I develop android app?	NaN	0
201841	201841	303951	174364	How can I create an Android app?	NaN	0
363362	363362	493340	493341	NaN	My Chinese name is Haichao Yu. What English na...	0

In [0]:

```
#filling it with empty string
df = df.fillna('')
```

```
#looking it again
df[df.isna().any(1)]
```

Out[0]:

id	qid1	qid2	question1	question2	is_duplicate

In [0]:

```
df.iloc[201841] # look at question2 and it fills with empty string
```

Out[0]:

```
id                                       201841
qid1                                     303951
qid2                                     174364
question1        How can I create an Android app?
question2
is_duplicate                                  0
Name: 201841, dtype: object
```

3.Basic Feature Extraction

In [0]:

```
#1. frequency of qid1
df.groupby('qid1')['qid1'].transform('count')
```

Out[0]:

```
0          1
1          4
2          1
3          1
4          3
          ..
404285     2
404286    12
404287     1
404288     1
404289     1
Name: qid1, Length: 404290, dtype: int64
```

In [0]:

```
# frequency of qid2
df.groupby('qid2')['qid2'].transform('count')
```

Out[0]:

```
0         1
1         1
2         1
3         1
4         1
         ..
404285    2
404286    1
404287    1
404288    1
404289    1
Name: qid2, Length: 404290, dtype: int64
```

In [0]:

```
# 2. length of question1 and question2 , here length includes space and individual chars
print(df['question1'].str.len())
print('='*50)
```

```
print(df['question2'].str.len())
```

```
0         66
1         51
2         73
3         50
4         76
          ..
404285    85
404286    41
404287    17
404288    94
404289    37
Name: question1, Length: 404290, dtype: int64
==================================================
0          57
1          88
2          59
3          65
4          39
         ...
404285     79
404286     42
404287     17
404288    127
404289     45
Name: question2, Length: 404290, dtype: int64
```

In [0]:

```
#3. number of words in each question
print(df['question1'].apply(lambda x: len(x.split(' '))))
print('='*50)
print(df['question2'].apply(lambda x: len(x.split(' '))))
```

```
0         14
1          8
2         14
3         11
4         13
          ..
404285    14
404286     8
404287     4
404288    17
404289     8
Name: question1, Length: 404290, dtype: int64
==================================================
0         12
1         13
2         10
3          9
4          7
          ..
404285    13
404286     9
404287     3
404288    25
404289    10
Name: question2, Length: 404290, dtype: int64
```

In [0]:

```
# 4. number of common words in question1 and question2 for just first row
print(set(map(lambda x:x.lower().strip(), df['question1'][0].split(' '))))
print(set(map(lambda x:x.lower().strip() , df['question2'][0].split(' '))))
print('='*25, 'Common words in ques1 and ques2 in row1', '='*25)
set(map(lambda x:x.lower().strip(), df['question1'][0].split(' '))) & set(map(lambda
x:x.lower().strip() , df['question2'][0].split(' ')))
```

```
{'what', 'step', 'by', 'is', 'share', 'invest', 'guide', 'the', 'market', 'india?', 'in', 'to'}
{'what', 'step', 'by', 'is', 'share', 'invest', 'guide', 'the', 'market?', 'in', 'to'}
========================= Common words in ques1 and ques2 in row1 =========================
```

Out[0]:

```
{'by', 'guide', 'in', 'invest', 'is', 'share', 'step', 'the', 'to', 'what'}
```

In [0]:

```
# 5. total number of words in ques1 and ques2 for first row
print('Number of words in question1 in row1')
print(list(map(lambda x:x.lower().strip() ,df['question1'][0].split(' '))))
print(len(list(map(lambda x:x.lower().strip() ,df['question1'][0].split(' ')))))
print('='*50)
print('Number of words in question2 in row2')
print(list(map(lambda x: x.lower().strip(), df['question2'][0].split(' '))))
print(len(list(map(lambda x: x.lower().strip(), df['question2'][0].split(' ')))))
```

```
Number of words in question1 in row1
['what', 'is', 'the', 'step', 'by', 'step', 'guide', 'to', 'invest', 'in', 'share', 'market',
'in', 'india?']
14
==================================================
Number of words in question2 in row2
['what', 'is', 'the', 'step', 'by', 'step', 'guide', 'to', 'invest', 'in', 'share', 'market?']
12
```

In [0]:

```
# 6. percentage of word share in row1 ==> number of common words/number of total words in row1
len(set(map(lambda x: x.lower().strip(), df['question1'][0].split(' '))) & set(map(lambda x: x.lower
().strip(), df['question2'][0].split(' ')))) /(len(list(map(lambda x:x.lower().strip() ,df['questio
n1'][0].split(' ')))) + len(list(map(lambda x: x.lower().strip(), df['question2'][0].split(' ')))))
```

Out[0]:

```
0.38461538461538464
```

In [0]:

```
os.path.isfile('/content/MyDrive/My Drive/Applied AI/Case studies/1.
Quora/df_fe_without_preprocessing_train.csv')
```

Out[0]:

```
True
```

In [0]:

```
# Function to accompany all these things
if os.path.isfile('/content/MyDrive/My Drive/Applied AI/Case studies/1.
Quora/df_fe_without_preprocessing_train.csv'):
    df = pd.read_csv('/content/MyDrive/My Drive/Applied AI/Case studies/1.
Quora/df_fe_without_preprocessing_train.csv',encoding='latin-1')

else:
    df['freq_qid1'] = df.groupby('qid1')['qid1'].transform('count')
    df['freq_qid2'] = df.groupby('qid2')['qid2'].transform('count')
    df['q1len'] = df['question1'].str.len()
    df['q2len'] = df['question2'].str.len()
    df['q1_n_words'] = df['question1'].apply(lambda row: len(row.split(" ")))
    df['q2_n_words'] = df['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)
    df['word_Common'] = df.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))
    df['word_Total'] = df.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))
    df['word_share'] = df.apply(normalized_word_share, axis=1)

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

    df.to_csv("df_fe_without_preprocessing_train.csv", index=False)

df.head()
```

Out[0]:

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common
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	66	57	14	12	10.0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	4	1	51	88	8	13	4.0
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0	1	1	73	59	14	10	4.0
3	3	7	8	Why am I mentally very lonely? How can I solve...	Find the remainder when [math]23^{24}[/math] i...	0	1	1	50	65	11	9	0.0
4	4	9	10	Which one dissolve in water quikly sugar, salt...	Which fish would survive in salt water?	0	3	1	76	39	13	7	2.0

3.1 Data Analysis in extracted features

In [0]:

```
print('min number of words in a question1: ',min(df['q1_n_words']) )
print('min number of words in a question2: ',min(df['q2_n_words']) )
print('Number of question wiht min length [question1]: ', len(df[df['q1_n_words']==1]))
print('Number of question wiht min length [question2]: ', len(df[df['q2_n_words']==1]))
```

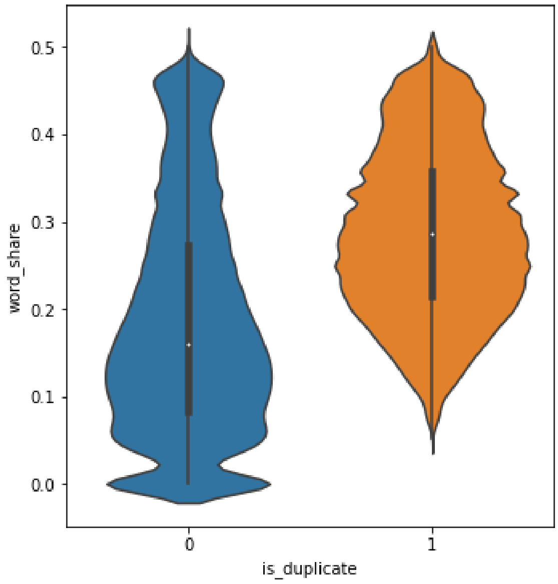
```
min number of words in a question1:  1
min number of words in a question2:  1
Number of question wiht min length [question1]:  67
Number of question wiht min length [question2]:  24
```

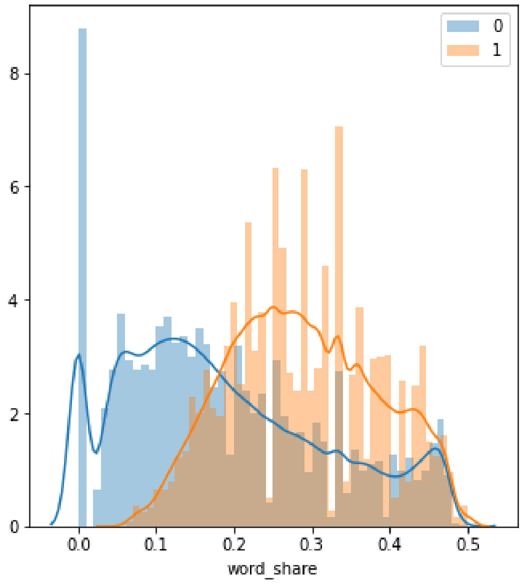
3.2 Featured word share

In [0]:

```
plt.figure(figsize=(12,6))
plt.subplot(1,2,1)
sns.violinplot(x='is_duplicate', y='word_share', data=df)
```

```
plt.subplot(1,2,2)
sns.distplot(df[df['is_duplicate']==0]['word_share'], label='0')
sns.distplot(df[df['is_duplicate']==1]['word_share'], label='1')
plt.legend()
plt.show()
```



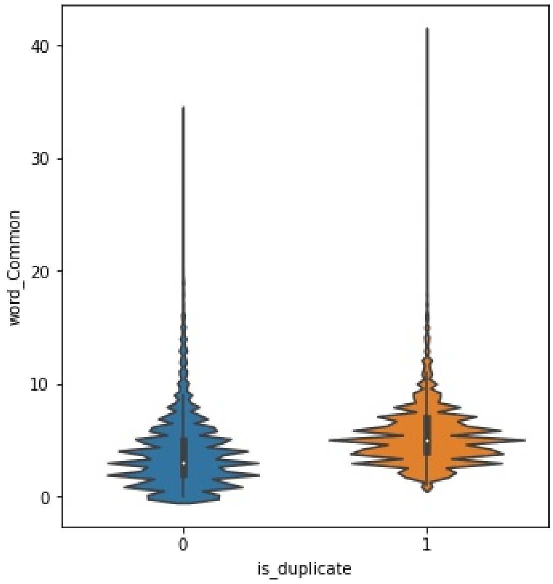


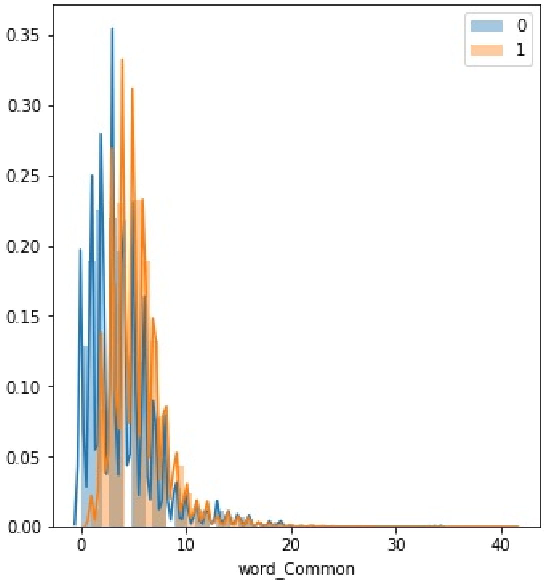
3.3 Word common

In [0]:

```
plt.figure(figsize=(12,6))
plt.subplot(1,2,1)
sns.violinplot(x='is_duplicate', y='word_Common', data=df)

plt.subplot(1,2,2)
sns.distplot(df[df['is_duplicate']==0]['word_Common'], label='0')
sns.distplot(df[df['is_duplicate']==1]['word_Common'], label='1')
plt.legend()
plt.show()
```





4.Preprocessing

- Removing html tags
- Removing Punctuations
- Performing stemming

- Removing Stopwords
- Expanding contractions etc.

In [0]:

```
def preprocess(x):

    x = x.str.lower()

    #expanding contradictions
    x = x.replace(",000,000", "m").replace(",000", "k").replace("′", "'").replace("’", "'")\
                            .replace("won't", "will not").replace("cannot", "can not").replace("can'
", "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("'re", " 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)

    #matches any non-alpha numeric a d substitue them with space ie ' '
    pattern = re.compile('\W')
    if type(x)==type(''):
      x = re.sub(pattern, ' ',x)

    #stemming the words
    porter = PorterStemmer()

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

    return x
```

5.Extracting 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 First 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 http://chairnerd.seatgeek.com/fuzzywuzzy-fuzzy-string-matching-in-python/

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

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

- **token_set_ratio** : https://github.com/seatgeek/fuzzywuzzy#usage 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 [0]:

```
print(len(set(['a','b','c']) & (set(['b','c', 'd']))))
```

```
2
```

In [0]:

```
Stop_Words = stopwords.words('english')
SAFE_DIV = 0.0001

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

    #split the questions into tokens
    q1_tokens = q1.split()
    q2_tokens = q2.split()

    if (q1_tokens==0) or (q2_tokens==0):
        return get_token_features

    #remove stop_words in question
    q1_words = set([i for i in q1_tokens if i not in Stop_Words])
    q2_words = set([i for i in q2_tokens if i not in Stop_Words])

    #get the stop words in question
    q1_stop_words = set([i for i in q1_tokens if i in Stop_Words])
    q2_stop_words = set([i for i in q2_tokens if i in Stop_Words])

    #get the common non_stop word from question
    common_word_count = len(q1_words & q2_words)

    #get the common stopword from question
    common_stop_word_count = len(q1_stop_words & q2_stop_words)

    #get the common token (ie before removing stop words)
    common_token_count = len(set(q1_tokens) & set(q2_tokens))

    token_feature[0] = common_word_count/(min(len(q1_words)&len(q2_words))+SAFE_DIV)
    token_feature[1] = common_word_count/max((len(q1_words)&len(q2_words))+SAFE_DIV)
    token_feature[2] = common_stop_word_count/(min(len(q1_stop_words)&len(q2_stop_words))+SAFE_DIV)
```

```
    token_feature[3] = common_stop_word_count/(max(len(q1_stop_words)&len(q2_stop_words))+SAFE_DIV)
    token_feature[4] = common_token_count/(min(len(q1_tokens)&len(q2_tokens))+SAFE_DIV)
    token_feature[5] = common_token_count/(max(len(q1_tokens)&len(q2_tokens))+SAFE_DIV)

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

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

    #difference bw lenght of two questions
    token_feature[8] = abs(len(q1_tokens) - len(q2_tokens))

    #average of length of two questions
    token_feature[9] = (len(q1_tokens) + len(q2_tokens))/2

    return token_feature
```

In [0]:

```
#check what distance.lcsubstrings return
print(list(distance.lcsubstrings('Kevin peterson', 'Alviron peterson'))[0])
print(len(list(distance.lcsubstrings('Kevin peterson', 'Alviron peterson'))[0]))
```

```
n peterson
10
```

In [0]:

```
#get the substring ratio
def get_longest_substring_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)
```

In [0]:

```
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_DIV)
    token_features[1] = common_word_count / (max(len(q1_words), len(q2_words)) + SAFE_DIV)
    token_features[2] = common_stop_count / (min(len(q1_stops), len(q2_stops)) + SAFE_DIV)
    token_features[3] = common_stop_count / (max(len(q1_stops), len(q2_stops)) + SAFE_DIV)
    token_features[4] = common_token_count / (min(len(q1_tokens), len(q2_tokens)) + SAFE_DIV)
    token_features[5] = common_token_count / (max(len(q1_tokens), len(q2_tokens)) + SAFE_DIV)
```

```
    token_features[5] = common_token_count / (max(len(q1_tokens), len(q2_tokens)) + SAFE_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["question2"]), 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
    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 tokens alpha
betically, and
    # then joining them back into a string We then compare the transformed strings with a simple r
atio().
    df["token_sort_ratio"]      = df.apply(lambda x: fuzz.token_sort_ratio(x["question1"],
x["question2"]), axis=1)
    df["fuzz_ratio"]            = df.apply(lambda x: fuzz.QRatio(x["question1"], x["question2"]), ax
is=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["question1"], x["qu
estion2"]), axis=1)

    return df
```

In [0]:

```
os.path.exists('/content/MyDrive/My Drive/Applied AI/Case studies/1. Quora/nlp_features_train.csv'
)
```

Out[0]:

```
True
```

In [0]:

```python
if os.path.isfile('/content/MyDrive/My Drive/Applied AI/Case studies/1.
Quora/nlp_features_train.csv'):
    df = pd.read_csv('/content/MyDrive/My Drive/Applied AI/Case studies/1.
Quora/nlp_features_train.csv',encoding='latin-1')
    df.fillna('')
else:
    print("Extracting features for train:")
    df = pd.read_csv("train.csv")
    df = extract_features(df)
    df.to_csv("nlp_features_train.csv", index=False)
df.head(2)
```

Out[0]:

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	firs
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	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	
1	1	3	4	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	

6.Analysis of extracted Fuzzy features

- Creating Word Cloud of Duplicates and Non-Duplicates Question pairs
- We can observe the most frequent occuring words

In [0]:

```python
print((np.dstack([['i am prem kumar'], ['i am a data scientist']]).flatten()))
print(len(np.dstack([['i am prem kumar'], ['i am a data scientist']]).flatten()))
```

```
['i am prem kumar' 'i am a data scientist']
2
```

In [0]:

```python
df_duplicate = df[df['is_duplicate']==0]
df_nonduplicate = df[df['is_duplicate']==1]

# Converting 2d array of q1 and q2 and flatten the array: like {{1,2},{3,4}} to {1,2,3,4}
p = np.dstack([df_duplicate['question1'], df_duplicate['question2']]).flatten()
n = np.dstack([df_nonduplicate['question1'], df_nonduplicate['question2']]).flatten()

#no of data points in duplicate and non-duplicate
print ("Number of data points in class 1 (duplicate pairs) :",len(p))
print ("Number of data points in class 0 (non duplicate pairs) :",len(n))
```

```
Number of data points in class 1 (duplicate pairs) : 510054
Number of data points in class 0 (non duplicate pairs) : 298526
```

In [0]:

```python
#Saving the np array into a text file
np.savetxt('train_p.txt', p, delimiter=' ', fmt='%s')
np.savetxt('train_n.txt', n, delimiter=' ', fmt='%s')
```

In [0]:

```python
# reading the text files and removing the Stop Words:
textp_w = open('/content/MyDrive/My Drive/Applied AI/Case studies/1. Quora/train_p.txt', encoding=
'latin-1').read()
textn_w = open('/content/MyDrive/My Drive/Applied AI/Case studies/1. Quora/train_n.txt', encoding=
'latin-1').read()
```

```
'latin-1').read()

print ("Total number of words in duplicate pair questions :",len(textp_w))
print ("Total number of words in non duplicate pair questions :",len(textn_w))
```

```
Total number of words in duplicate pair questions : 16109886
Total number of words in non duplicate pair questions : 33193130
```

6.1Word cloud

In [0]:

```
stop_words = set(Stop_Words)
stop_words.add("said")
stop_words.add("br")
stop_words.add(" ")

stop_words.remove("not")
stop_words.remove("no")
```

In [0]:

```
wc = WordCloud(background_color='white', max_words=len(textp_w), stopwords=stop_words)
wc.generate(textp_w)

plt.figure(figsize=(12,8))
print ("Word Cloud for Duplicate Question pairs")
plt.imshow(wc, interpolation='bilinear')
plt.axis("off")
plt.show()
```

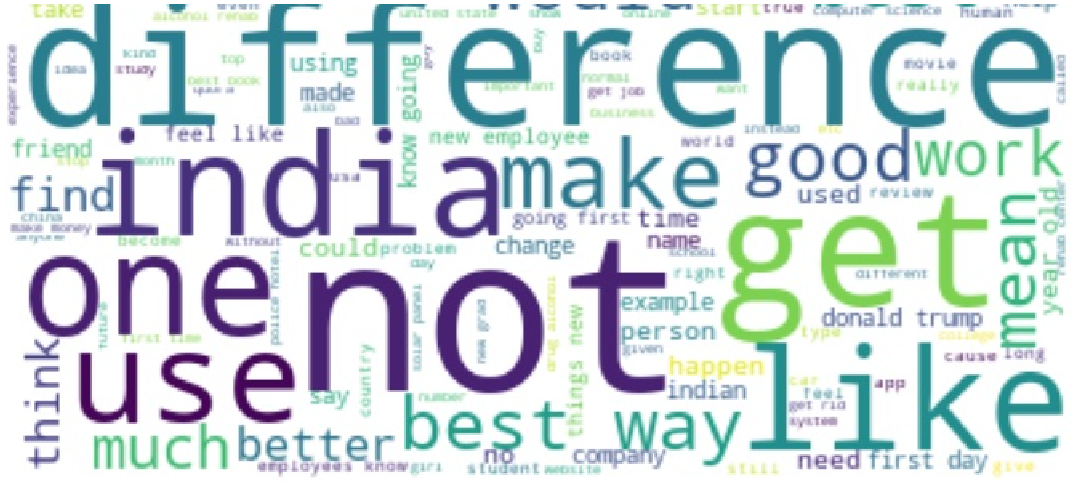
```
Word Cloud for Duplicate Question pairs
```

In [0]:

```
wc = WordCloud(background_color='white', max_words=len(textn_w), stopwords=stop_words)
wc.generate(textn_w)

plt.figure(figsize=(12,8))
print ("Word Cloud for Non Duplicate Question pairs")
plt.imshow(wc, interpolation='bilinear')
plt.axis("off")
plt.show()
```

```
Word Cloud for Non Duplicate Question pairs
```

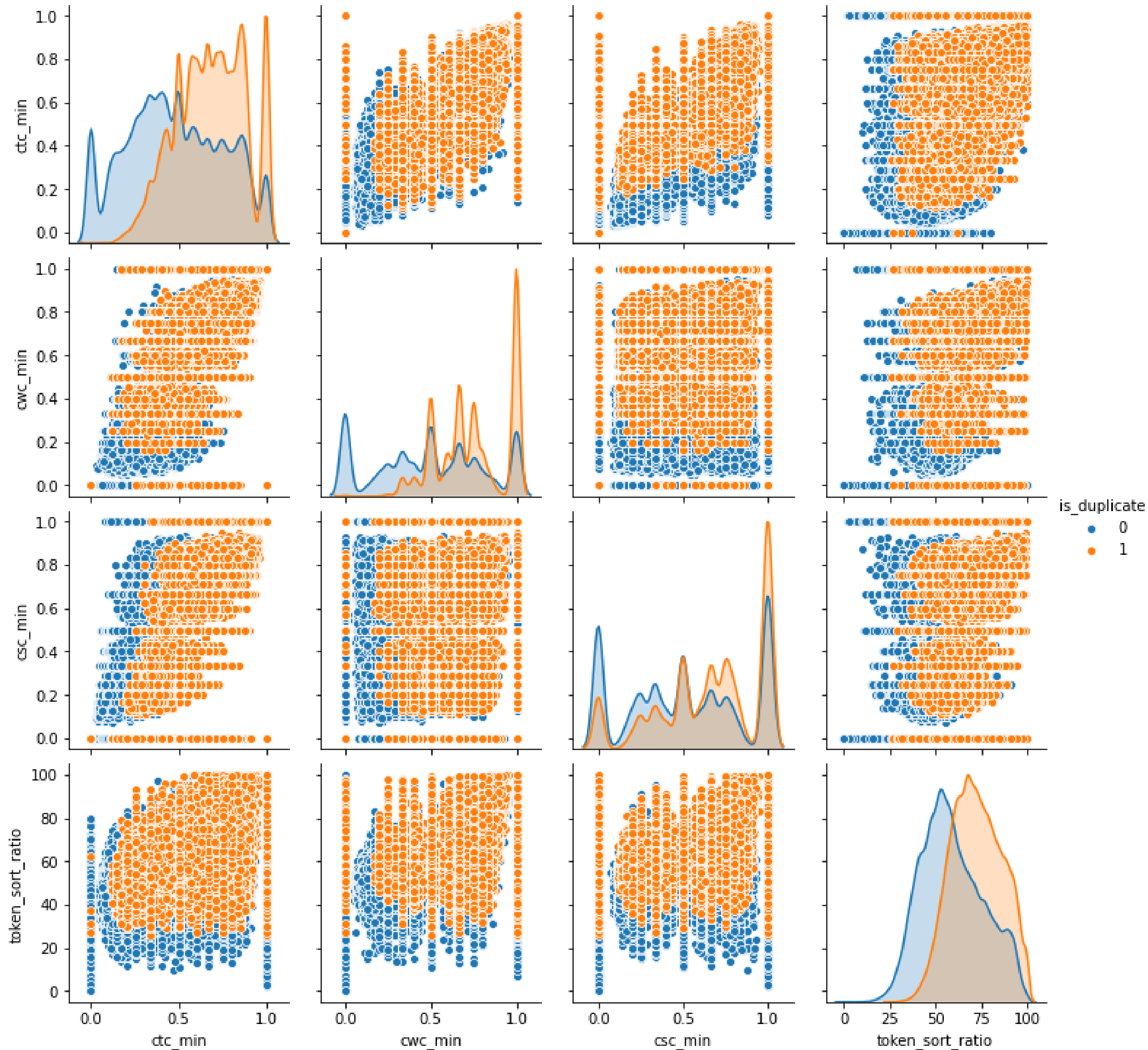


6.2 Pair plot

In [0]:

```
n = df.shape[0]

sns.pairplot(df[['ctc_min', 'cwc_min', 'csc_min', 'token_sort_ratio', 'is_duplicate']][0:n], hue='is_duplicate', vars=['ctc_min', 'cwc_min', 'csc_min', 'token_sort_ratio'])
plt.show()
```



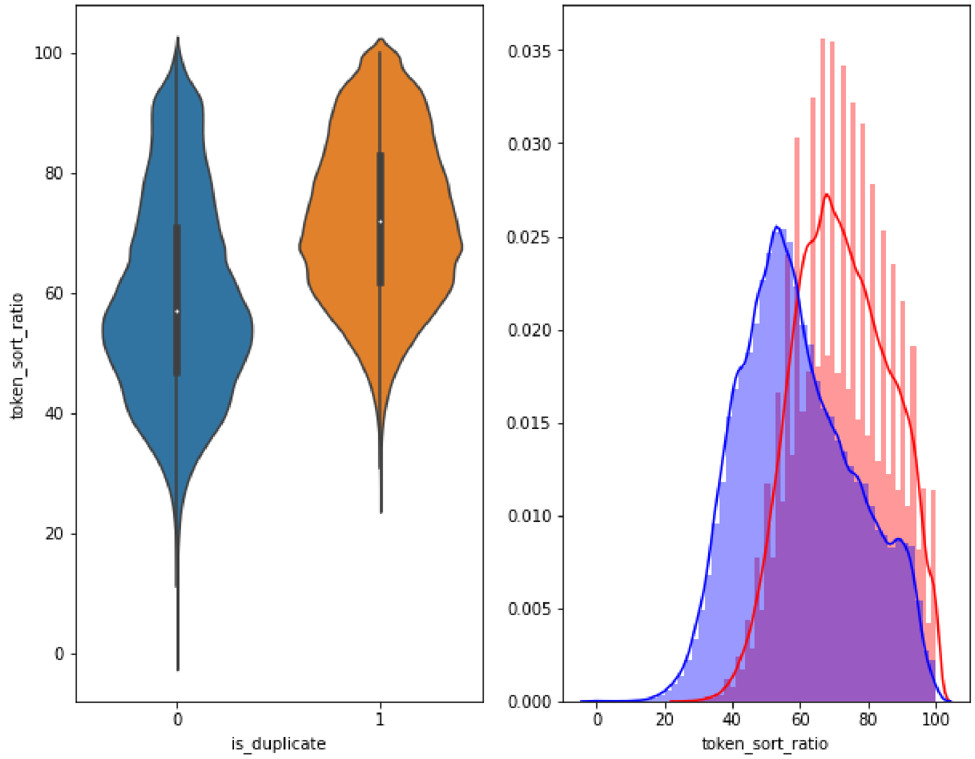
6.3 Violin Plot

In [0]:

```
# Distribution of the token_sort_ratio
plt.figure(figsize=(10, 8))

plt.subplot(1,2,1)
sns.violinplot(x = 'is_duplicate', y = 'token_sort_ratio', data = df[0:] , )

plt.subplot(1,2,2)
sns.distplot(df[df['is_duplicate'] == 1.0]['token_sort_ratio'][0:] , label = "1", color = 'red')
sns.distplot(df[df['is_duplicate'] == 0.0]['token_sort_ratio'][0:] , label = "0" , color = 'blue' )
plt.show()
```

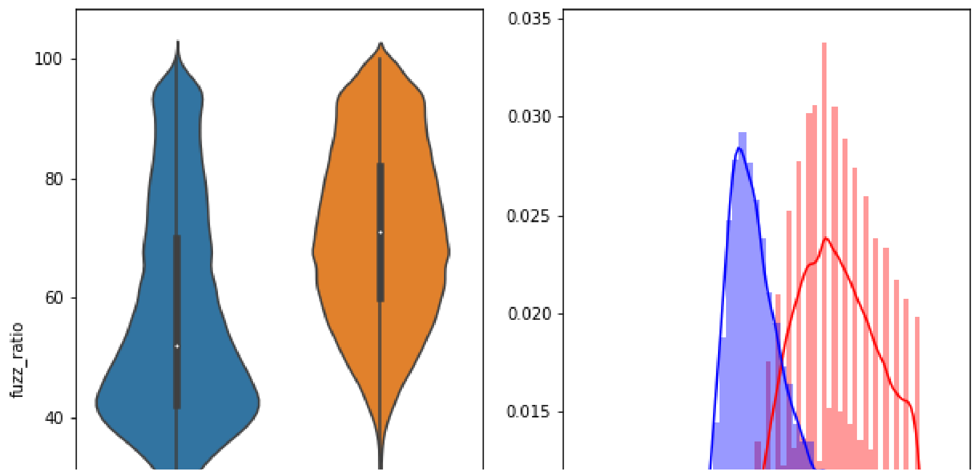


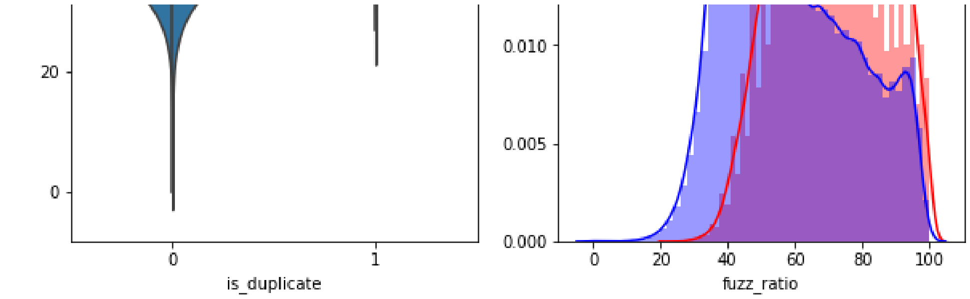
In [0]:

```
plt.figure(figsize=(10, 8))

plt.subplot(1,2,1)
sns.violinplot(x = 'is_duplicate', y = 'fuzz_ratio', data = df[0:] , )

plt.subplot(1,2,2)
sns.distplot(df[df['is_duplicate'] == 1.0]['fuzz_ratio'][0:] , label = "1", color = 'red')
sns.distplot(df[df['is_duplicate'] == 0.0]['fuzz_ratio'][0:] , label = "0" , color = 'blue' )
plt.show()
```





7.Visualisation of features using t-SNE

In [0]:

```
#taking only sample of 5000 to visualize it
df_sampled = df[0:5000]
df.head()
```

Out[0]:

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	firs
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	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	
1	1	3	4	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	
2	2	5	6	how can i increase the speed of my internet co...	how can internet speed be increased by hacking...	0	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	
3	3	7	8	why am i mentally very lonely how can i solve...	find the remainder when math 23 24 math i...	0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	
4	4	9	10	which one dissolve in water quikly sugar salt...	which fish would survive in salt water	0	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	

In [0]:

```
X = MinMaxScaler().fit_transform(df_sampled[['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']])
y = df_sampled['is_duplicate'].values
```

7.1 t-SNE - 2D

In [0]:

```
tsne_2d = TSNE(n_components=2, init='random', random_state=42, method='barnes_hut', n_iter=1000, ve
rbose=2, angle=0.5).fit_transform(X)
```

```
[t-SNE] Computing 91 nearest neighbors...
[t-SNE] Indexed 5000 samples in 0.021s...
[t-SNE] Computed neighbors for 5000 samples in 0.391s...
[t-SNE] Computed conditional probabilities for sample 1000 / 5000
[t-SNE] Computed conditional probabilities for sample 2000 / 5000
```

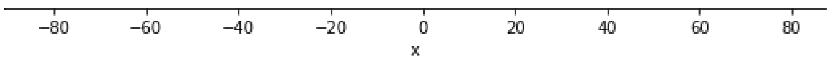
```
[t-SNE] Computed conditional probabilities for sample 2000 / 5000
[t-SNE] Computed conditional probabilities for sample 3000 / 5000
[t-SNE] Computed conditional probabilities for sample 4000 / 5000
[t-SNE] Computed conditional probabilities for sample 5000 / 5000
[t-SNE] Mean sigma: 0.116557
[t-SNE] Computed conditional probabilities in 0.315s
[t-SNE] Iteration 50: error = 82.2403336, gradient norm = 0.0485435 (50 iterations in 2.200s)
[t-SNE] Iteration 100: error = 70.3681030, gradient norm = 0.0092659 (50 iterations in 1.621s)
[t-SNE] Iteration 150: error = 68.5769806, gradient norm = 0.0058538 (50 iterations in 1.520s)
[t-SNE] Iteration 200: error = 67.7360840, gradient norm = 0.0040857 (50 iterations in 1.573s)
[t-SNE] Iteration 250: error = 67.2339020, gradient norm = 0.0052474 (50 iterations in 1.577s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 67.233902
[t-SNE] Iteration 300: error = 1.7625930, gradient norm = 0.0011850 (50 iterations in 1.706s)
[t-SNE] Iteration 350: error = 1.3605168, gradient norm = 0.0004797 (50 iterations in 1.684s)
[t-SNE] Iteration 400: error = 1.1939461, gradient norm = 0.0002759 (50 iterations in 1.691s)
[t-SNE] Iteration 450: error = 1.1049948, gradient norm = 0.0001849 (50 iterations in 1.724s)
[t-SNE] Iteration 500: error = 1.0508957, gradient norm = 0.0001383 (50 iterations in 1.700s)
[t-SNE] Iteration 550: error = 1.0155830, gradient norm = 0.0001115 (50 iterations in 1.698s)
[t-SNE] Iteration 600: error = 0.9920100, gradient norm = 0.0000971 (50 iterations in 1.714s)
[t-SNE] Iteration 650: error = 0.9761610, gradient norm = 0.0000874 (50 iterations in 1.707s)
[t-SNE] Iteration 700: error = 0.9652733, gradient norm = 0.0000820 (50 iterations in 1.732s)
[t-SNE] Iteration 750: error = 0.9575369, gradient norm = 0.0000762 (50 iterations in 1.690s)
[t-SNE] Iteration 800: error = 0.9517581, gradient norm = 0.0000729 (50 iterations in 1.714s)
[t-SNE] Iteration 850: error = 0.9465392, gradient norm = 0.0000655 (50 iterations in 1.684s)
[t-SNE] Iteration 900: error = 0.9419289, gradient norm = 0.0000655 (50 iterations in 1.697s)
[t-SNE] Iteration 950: error = 0.9379401, gradient norm = 0.0000598 (50 iterations in 1.696s)
[t-SNE] Iteration 1000: error = 0.9343591, gradient norm = 0.0000603 (50 iterations in 1.684s)
[t-SNE] KL divergence after 1000 iterations: 0.934359
```

In [0]:

```
df_2d = pd.DataFrame({'x':tsne_2d[:,0], 'y':tsne_2d[:,1] ,'label':y})

# draw the plot in appropriate place in the grid
sns.lmplot(data=df_2d, x='x', y='y', hue='label', fit_reg=False, size=8,palette="Set1",markers=['s'
,'o'])
plt.title("perplexity : {} and max_iter : {}".format(30, 1000))
plt.show()
```

```
/usr/local/lib/python3.6/dist-packages/seaborn/regression.py:573: UserWarning: The `size`
parameter has been renamed to `height`; please update your code.
  warnings.warn(msg, UserWarning)
```



7.2 t-SNE - 3D

In [0]:

```
tsne_3d = TSNE(
    n_components=3,
    init='random', # pca
    random_state=101,
    method='barnes_hut',
    n_iter=1000,
    verbose=2,
    angle=0.5
).fit_transform(X)
```

```
[t-SNE] Computing 91 nearest neighbors...
[t-SNE] Indexed 5000 samples in 0.017s...
[t-SNE] Computed neighbors for 5000 samples in 0.378s...
[t-SNE] Computed conditional probabilities for sample 1000 / 5000
[t-SNE] Computed conditional probabilities for sample 2000 / 5000
[t-SNE] Computed conditional probabilities for sample 3000 / 5000
[t-SNE] Computed conditional probabilities for sample 4000 / 5000
[t-SNE] Computed conditional probabilities for sample 5000 / 5000
[t-SNE] Mean sigma: 0.116557
[t-SNE] Computed conditional probabilities in 0.310s
[t-SNE] Iteration 50: error = 80.3825836, gradient norm = 0.0316220 (50 iterations in 9.710s)
[t-SNE] Iteration 100: error = 69.1291580, gradient norm = 0.0034171 (50 iterations in 4.833s)
[t-SNE] Iteration 150: error = 67.6390839, gradient norm = 0.0017523 (50 iterations in 4.328s)
[t-SNE] Iteration 200: error = 67.0798187, gradient norm = 0.0011316 (50 iterations in 4.286s)
[t-SNE] Iteration 250: error = 66.7545319, gradient norm = 0.0010951 (50 iterations in 4.253s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 66.754532
[t-SNE] Iteration 300: error = 1.4973605, gradient norm = 0.0006769 (50 iterations in 5.712s)
[t-SNE] Iteration 350: error = 1.1548493, gradient norm = 0.0001913 (50 iterations in 7.629s)
[t-SNE] Iteration 400: error = 1.0096524, gradient norm = 0.0000907 (50 iterations in 7.676s)
[t-SNE] Iteration 450: error = 0.9380181, gradient norm = 0.0000588 (50 iterations in 7.538s)
[t-SNE] Iteration 500: error = 0.8995014, gradient norm = 0.0000524 (50 iterations in 7.472s)
[t-SNE] Iteration 550: error = 0.8804497, gradient norm = 0.0000466 (50 iterations in 7.407s)
[t-SNE] Iteration 600: error = 0.8691350, gradient norm = 0.0000411 (50 iterations in 7.322s)
[t-SNE] Iteration 650: error = 0.8599784, gradient norm = 0.0000348 (50 iterations in 7.240s)
[t-SNE] Iteration 700: error = 0.8518915, gradient norm = 0.0000336 (50 iterations in 7.289s)
[t-SNE] Iteration 750: error = 0.8449173, gradient norm = 0.0000285 (50 iterations in 7.308s)
[t-SNE] Iteration 800: error = 0.8392022, gradient norm = 0.0000273 (50 iterations in 7.289s)
[t-SNE] Iteration 850: error = 0.8342683, gradient norm = 0.0000274 (50 iterations in 7.265s)
[t-SNE] Iteration 900: error = 0.8303084, gradient norm = 0.0000280 (50 iterations in 7.222s)
[t-SNE] Iteration 950: error = 0.8269118, gradient norm = 0.0000239 (50 iterations in 7.204s)
[t-SNE] Iteration 1000: error = 0.8239461, gradient norm = 0.0000245 (50 iterations in 7.211s)
[t-SNE] KL divergence after 1000 iterations: 0.823946
```

In [0]:

```
def configure_plotly_browser_state():
  import IPython
  display(IPython.core.display.HTML('''
        <script src="/static/components/requirejs/require.js"></script>
        <script>
          requirejs.config({
            paths: {
              base: '/static/base',
              plotly: 'https://cdn.plot.ly/plotly-latest.min.js?noext',
            },
          });
        </script>
        '''))
```

In [0]:

```
configure_plotly_browser_state()

trace1 = go.Scatter3d(
    x=tsne_3d[:,0],
```

```
    y=tsne_3d[:,1],
    z=tsne_3d[:,2],
    mode='markers',
    marker=dict(
        sizemode='diameter',
        color = y,
        colorscale = 'Portland',
        colorbar = dict(title = 'duplicate'),
        line=dict(color='rgb(255, 255, 255)'),
        opacity=0.75
    )
)

data=[trace1]
layout=dict(height=800, width=800, title='3d embedding with engineered features')
fig=dict(data=data, layout=layout)
py.iplot(fig, filename='3DBubble')
```

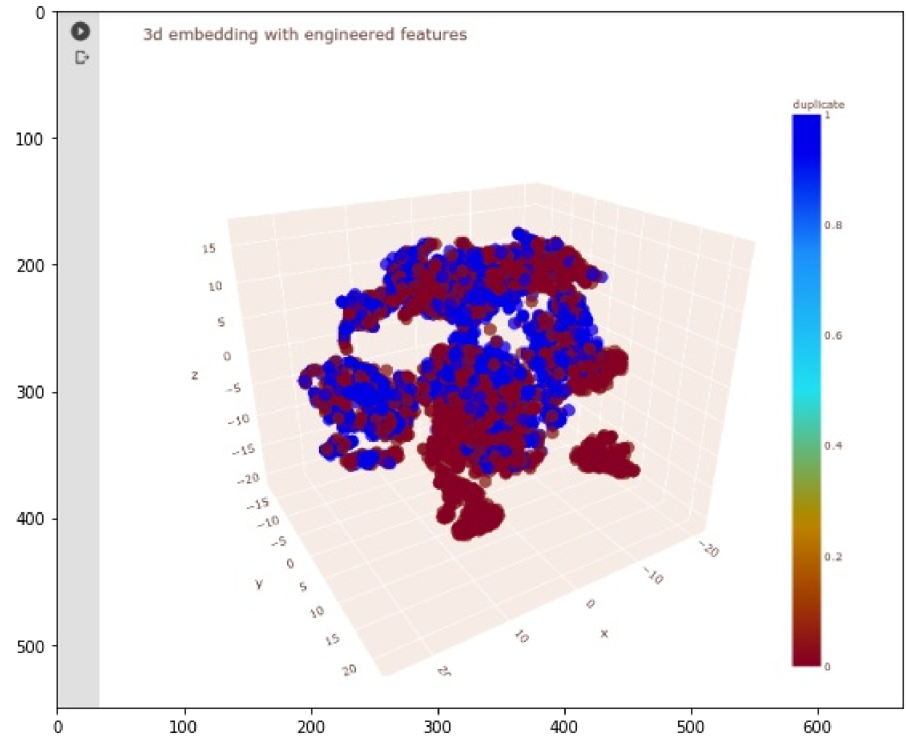
In [0]:

```
img = cv2.imread('/content/MyDrive/My Drive/Applied AI/Case studies/1. Quora/plotly-fig.png')

plt.figure(figsize=(12,8))
plt.imshow(img)
```

Out[0]:

<matplotlib.image.AxesImage at 0x7fa240f62048>



8. TFIDF-W2V

In [4]:

```
df = pd.read_csv('/home/ubuntu/Quora/*Assign 22 -Quora/nlp_features_train.csv', encoding='latin-1'
)
df.head()
```

Out[4]:

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	...	ctc_max	last_word_eq	first_word_
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	0.999980	0.833319	0.999983	0.999983	...	0.785709	0.0	
1	1	3	4	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0	0.799984	0.399996	0.749981	0.599988	...	0.466664	0.0	
2	2	5	6	how can i increase the speed of my internet co...	how can internet speed be increased by hacking...	0	0.399992	0.333328	0.399992	0.249997	...	0.285712	0.0	
3	3	7	8	why am i mentally very lonely how can i solve...	find the remainder when math 23 24 math i...	0	0.000000	0.000000	0.000000	0.000000	...	0.000000	0.0	
4	4	9	10	which one dissolve in water quikly sugar salt...	which fish would survive in salt water	0	0.399992	0.199998	0.999950	0.666644	...	0.307690	0.0	

5 rows × 21 columns

In [5]:

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

Note:

- We need to apply tfidf weightedW2V on cleaned data (nlp_features_train.csv) rather than train.csv.
- Also we need to split the data before applying tf-idf weighted W2V

In [6]:

```
#we need only questions1 and question2 and id to merge using it
df = df[['id', 'question1', 'question2', 'is_duplicate']]
df.head()
```

Out[6]:

	id	question1	question2	is_duplicate
0	0	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	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0
2	2	how can i increase the speed of my internet co...	how can internet speed be increased by hacking...	0
3	3	why am i mentally very lonely how can i solve...	find the remainder when math 23 24 math i...	0
4	4	which one dissolve in water quikly sugar salt...	which fish would survive in salt water	0

8.1 Splitting the data

In [7]:

```
print(df.shape)
print(df.iloc[:,-1:].shape)
```

```
(404290, 4)
(404290, 1)
```

In [8]:

```
df_train, df_val, y_train, y_val = train_test_split(df, df.iloc[:, -1:], test_size = 0.3, random_st
ate=0 , stratify = df.iloc[:,-1:])
df_train, df_test, y_train, y_test = train_test_split(df_train, y_train, test_size= 0.3, random_sta
te=0, stratify = y_train)
```

In [9]:

```
print(df_train.shape)
print(df_val.shape)
print(df_test.shape)

print(y_train.shape)
print(y_val.shape)
print(y_test.shape)
```

```
(198102, 4)
(121287, 4)
(84901, 4)
(198102, 1)
(121287, 1)
(84901, 1)
```

In [16]:

```
df_train.head()
```

```
df_train.head()
```

Out[16]:

	id	question1	question2	is_duplicate
209577	209577	how do i use shall and should will and would ...	how do i use will and would in a sentence	0
17392	17392	is writing a good profession	can writing be a good profession	1
14251	14251	were there atheists in ancient mesopotamian ci...	were there atheists in ancient persia	0
265830	265830	has india really isolated pakistan globally i...	what do you think of russian troops arriving i...	0
123216	123216	which are the most visited temples of chhattis...	which are the most visited temples in chhattis...	1

In [17]:

```
df_val.head()
```

Out[17]:

	id	question1	question2	is_duplicate
40373	40373	what is the name of the italian song goes some...	what is the title of the slow song that goes l...	0
218089	218089	what are some ways for you to lose 40 pounds i...	is it safe to lose 40 pounds in 2 weeks	1
184729	184729	what are some good ways to detoxify one own body	what are the most effective ways to detoxify y...	1
218907	218907	how many hours of deep sleep delta wave porti...	what is the ideal amount of sleep time that a ...	0
224215	224215	what are some important lesson you learn from ...	what are some important lessons you learned ou...	0

In [18]:

```
df_test.head()
```

Out[18]:

	id	question1	question2	is_duplicate
372980	372980	how can i increase the traffic on my blog www...	how do i increase traffic on my site	1
14252	14252	what is the difference between pu leather and ...	are leather vans shoes made of real leather	0
102303	102303	which is correct 2 dozen of eggs cost 30 rup...	which one is correct 1 look out of the windo...	0
274316	274316	what are the best one liners	what are the best one liners in hindi	0
370597	370597	how can i start making money using internet	what is the easiest way to earn money using in...	1

8.2 IDF of words in questions

In [10]:

```
train_questions = df_train['question1'] + df_train['question2']
train_questions.head()
```

Out[10]:

```
209577    how do i use shall and should  will and would ...
17392     is writing a good profession can writing be a ...
14251     were there atheists in ancient mesopotamian ci...
265830    has india really isolated pakistan globally  i...
123216    which are the most visited temples of chhattis...
dtype: object
```

In [19]:

```
vec = TfidfVectorizer(min_df = 25)
vec.fit_transform(train_questions)

#zip of (word, idf values of word)  and then dict it
word2tfidf = dict(zip(vec.get_feature_names(), vec.idf_))
```

In [20]:

```
len(word2tfidf)
```

Out[20]:

```
7316
```

Note:

- As said in email, i tried different min_df values of 10, 20, 25 and it gives 12.8k, 8.5k, and 7.3k respectively. I am using min_df = 25 for 2 reasons. First one is it reduces the dimension and the second one, the questions are almost similar to each other and the words in questions repeating again and again

In [21]:

```
#sum of all idf values which will be useful to find weighted_tfidf_w2v ==> ( (idf_w1*vec_w1) + (id
f_w2*vec_w2) +...+(idf_wn*vec_wn))/(idf_w1+idf_w2+...+idf_wn)
#https://kite.com/python/answers/how-to-sum-the-values-in-a-dictionary-in-
python#:~:text=Use%20sum()%20to%20sum,values%20from%20the%20previous%20step.

sum_idf = sum(word2tfidf.values())
print(sum_idf)
```

```
63219.72464508459
```

8.3 Loading glove in spacy

In [2]:

```
glove = spacy.load('en_core_web_sm')

print(glove)
```

```
<spacy.lang.en.English object at 0x7f31f0a816a0>
```

In [16]:

```
#see what glove return when we given a sentence and its type
print(glove(df_train['question1'].iloc[0]))
print(type(glove(df_train['question1'].iloc[0])))
```

```
how do i use shall and should  will and would  can and could in a sentence
<class 'spacy.tokens.doc.Doc'>
```

In [17]:

```
for i in glove(df_train['question1'].iloc[0]): #we dont need to split it and i.vector gives the
vecotr representation of the word
    print((i, i.vector))
    print(len(i.vector))  #which gives dimension of each word
```

```
(how, array([-0.25642753, -1.651585  , -2.1492958 , -2.841151  , -0.38527584,
        2.9442854 ,  1.1803646 ,  0.25771916,  4.2077155 , -3.7638094 ,
        0.8159517 , -1.179973  , -1.6908273 , -0.77429676, -1.0198613 ,
        0.25888532,  2.2379441 , -2.775265  ,  2.6454005 , -3.402844  ,
       -0.8123921 ,  0.3909678 ,  1.4348501 ,  0.06442726, -0.08965635,
        0.06323573,  1.1758895 , -1.3840092 ,  1.2733849 , -0.3706682 ,
        8.229353  , -3.9226766 ,  3.9517229 ,  1.2850422 , -1.9552982 ,
```

```
       -3.0285926 ,  0.51044536,  1.8431818 ,  0.16051283,  5.5677285 ,
       -2.5549846 ,  2.0888383 , -4.9345465 ,  2.7583025 , -2.8520746 ,
        0.67331225, -1.9051372 , -1.1828032 , -3.6110253 ,  0.7943965 ,
       -1.1050334 ,  0.7351209 ,  7.117074  ,  0.3570062 ,  6.0055594 ,
        0.6539494 , -2.1824207 , -0.97305405,  0.886073  ,  0.5186693 ,
       -2.7837663 , -1.7447785 , -2.0322268 ,  2.2677383 ,  1.1464663 ,
       -0.67210156, -2.8589587 , -2.7366796 , -1.2349586 , -1.2178357 ,
       -0.86662954,  2.3929112 , -3.6356106 ,  0.84763104, -3.2111478 ,
        1.2897842 , -0.14211886,  2.671087  , -0.1927194 ,  0.95919174,
       -1.9453676 ,  2.4562008 , -1.5821563 , -1.7843827 ,  1.3448919 ,
        0.17707098,  2.9111865 , -0.8712585 , -2.3777854 , -1.6727947 ,
       -1.1056525 , -0.16875213,  1.3103461 ,  0.54000896,  0.67570496,
        4.0727477 ], dtype=float32))
96
(do, array([-0.07395066, -1.00178   , -0.7198461 ,  2.6952665 ,  1.1787028 ,
        3.1708126 , -0.78508043,  1.8313125 ,  1.976656  , -3.0945458 ,
        2.7640424 ,  2.5754075 ,  0.9179051 ,  1.2376269 , -1.3997297 ,
       -0.1344763 ,  1.6927705 ,  0.6454431 , -0.81977314,  1.7133493 ,
       -1.2242761 , -1.5546625 , -0.33322573, -0.38228086,  3.5537271 ,
        3.579337  , -4.769132  , -3.966068  ,  2.0802655 , -0.25107455,
       -1.3138151 ,  1.1911623 ,  0.2777772 ,  2.3845375 ,  0.7138606 ,
        0.98208255, -1.1053947 ,  0.1980946 ,  1.0509872 , -3.2584171 ,
       -1.4141047 ,  4.686612  ,  0.8876432 ,  0.92952305, -2.183546  ,
       -3.9811914 ,  1.0234544 , -1.1655209 ,  1.6853355 , -1.1085854 ,
       -3.9195406 , -1.3738762 ,  0.31924742,  0.83503556, -0.9004183 ,
       -0.25983804, -0.3704146 ,  2.8436527 , -0.1495097 ,  2.2576828 ,
        2.3335705 , -2.9186568 , -1.7025584 , -0.5160924 ,  0.13467723,
       -0.38445824,  2.2652688 ,  0.8888569 , -1.6762152 ,  0.83356667,
        1.0614992 , -3.9281464 , -1.0820308 , -3.65922   ,  0.31834733,
        4.321849  , -0.69890475, -2.8870554 ,  3.1046414 , -2.8803315 ,
        4.7620025 ,  2.4852495 , -0.68872845,  1.1090326 , -1.8962581 ,
        3.349251  ,  1.6775932 ,  0.02843451,  0.06870532,  3.410138  ,
       -0.918211  ,  2.4596777 , -0.6254596 , -7.150746  , -2.7112927 ,
       -1.0749812 ], dtype=float32))
96
(i, array([-1.07221472e+00, -1.71991539e+00,  3.59101081e+00, -1.92816329e+00,
       -4.77607250e-02,  4.19391346e+00,  3.16348886e+00, -2.12807941e+00,
       -7.41854489e-01,  5.71822882e-01, -5.06411672e-01,  7.19976187e-01,
       -5.92462301e-01,  2.27682501e-01, -1.23571134e+00, -1.10804915e-01,
        5.28477144e+00, -4.66782242e-01,  1.65800393e-01, -1.69914269e+00,
       -2.26735210e+00, -6.22627914e-01, -4.31932831e+00,  1.43344069e+00,
        1.85943019e+00,  7.39773846e+00, -1.94502378e+00, -9.73612070e-04,
       -5.05453777e+00, -8.20800245e-01, -1.06380332e+00,  2.42890906e+00,
       -2.19072151e+00, -1.70662570e+00,  7.29388297e-01,  5.30261397e-01,
       -4.06706762e+00,  6.11344433e+00,  1.18741345e+00,  7.60611892e-01,
       -1.19192529e+00, -3.38866568e+00,  1.05509186e+00, -2.08307362e+00,
        2.08184624e+00, -1.95567250e+00,  2.03372574e+00,  3.80959392e+00,
       -1.90612447e+00, -1.76105595e+00, -1.87076545e+00,  2.46954107e+00,
        5.67326903e-01, -2.68147302e+00, -3.10673785e+00,  3.77704453e+00,
       -2.85054803e-01,  2.48266816e-01, -2.91387582e+00,  7.89763153e-01,
        5.76890039e+00,  6.27124739e+00,  1.27420485e-01, -5.99805117e-01,
       -1.29484272e+00, -1.64279795e+00, -1.27427125e+00, -5.41530561e+00,
       -8.28331113e-01,  1.09653616e+00, -2.38027692e-01, -1.62775412e-01,
        2.59898067e-01,  1.85842490e+00, -2.41807365e+00,  3.96174192e-02,
        2.27299166e+00,  2.86062384e+00,  2.01246691e+00,  1.11632562e+00,
        9.46908057e-01, -3.02326649e-01, -2.02290797e+00, -6.70594454e-01,
        6.18272483e-01,  3.09108925e+00,  1.63820696e+00, -3.06159377e-01,
        3.86954069e+00,  3.48318505e+00, -7.98989654e-01, -2.45954418e+00,
       -3.80812788e+00, -3.69802999e+00, -6.25008047e-01, -2.15782118e+00],
      dtype=float32))
96
(use, array([-4.374754  , -3.1826646 , -1.6190226 ,  1.3185399 ,  4.077916  ,
        3.2887845 , -1.5160539 , -1.8746476 ,  2.6161003 , -1.9099436 ,
       -1.0752854 ,  3.9075637 , -2.461498  , -1.2244049 , -0.5238929 ,
       -2.0806403 ,  2.1253698 ,  3.5897965 , -0.09307623,  1.0125511 ,
        0.02710414,  2.7443326 , -0.98280233,  2.572997  ,  3.490713  ,
        3.0911255 , -3.3607087 , -0.5239498 , -0.04480743,  0.03356773,
       -0.59399784,  4.478144  ,  3.7941406 ,  3.553747  ,  2.2767682 ,
        2.5434852 ,  0.9518275 , -2.2591443 ,  1.4105704 , -2.038496  ,
        0.0440208 ,  4.351934  , -3.2287283 , -0.2567569 , -0.2235949 ,
       -2.2217908 ,  1.2189921 , -1.7828828 , -3.6545582 ,  1.8776078 ,
       -4.468121  , -2.0717325 , -1.1232454 , -0.16662705, -0.9959103 ,
        1.1080636 ,  0.7803321 ,  0.61057276,  0.8831149 , -0.6006123 ,
        3.197847  ,  6.432417  ,  0.7935058 ,  2.8843098 , -1.3444579 ,
       -1.1025096 ,  3.453412  ,  1.939812  , -0.8211528 ,  1.3005093 ,
       -2.0595143 , -3.8529541 , -2.073826  , -0.27010155, -1.0030627 ,
       -1.5831993 , -0.01426828, -3.9048653 , -0.08743124, -5.291999  ,
```

```
        2.155103  , -2.2803574 , -0.821892  ,  4.580947  , -4.2441573 ,
        1.1848104 ,  0.86967367,  0.18070653, -4.382216  ,  5.417105  ,
       -0.97301096, -1.8893895 ,  2.4958305 , -4.4917374 , -0.81330055,
       -0.03684807], dtype=float32))
96
(shall, array([ 0.61039025, -3.0055752 , -4.935487  , -1.2087038 ,  0.26708886,
       -0.5275141 , -0.95231676, -3.1807559 , -0.01380289, -0.9311544 ,
       -1.2969286 ,  0.30910328,  0.69077057,  0.43853864, -1.4694015 ,
       -1.6640726 ,  4.3107023 ,  1.4078577 , -3.0032415 ,  1.2277792 ,
       -2.2170854 ,  0.7458726 , -0.97636336,  5.5367136 , -0.3936028 ,
        1.2207894 , -1.7272977 ,  2.001443  ,  2.5215302 , -0.8391339 ,
        2.3533556 ,  0.01482135, -0.42870638,  0.5009699 ,  3.3167746 ,
       -0.19168365,  1.5021235 ,  2.9184263 , -1.0354505 ,  2.203916  ,
        1.7854083 ,  5.080969  ,  0.26401138, -0.23679733, -2.3544347 ,
       -3.5549593 ,  1.9054408 , -1.3960866 ,  1.9885851 , -1.9838524 ,
        0.4386328 ,  0.48981172,  0.22554308, -2.4164693 ,  0.49454933,
       -0.18935847, -0.6204841 ,  3.1495001 ,  3.7578926 , -4.255908  ,
        3.178209  ,  0.548596  , -1.6972358 , -0.2660172 , -2.6673596 ,
        1.4619578 ,  0.9045295 , -1.8480155 , -1.5078435 ,  3.1387417 ,
        2.834002  , -1.8379993 ,  0.8137278 ,  2.0027342 , -0.3276403 ,
       -0.14186215,  2.5559177 ,  1.9241382 ,  0.38220072, -0.15598056,
       -1.272683  ,  1.4823936 , -0.20603439, -2.6638765 , -0.46880865,
       -0.61137   , -2.4376752 , -2.3403718 ,  0.3913221 ,  3.9619288 ,
        0.22001705, -0.01393253, -0.85681725, -0.43951356, -4.0042863 ,
       -2.8467412 ], dtype=float32))
96
(and, array([-1.5815005 , -3.5132017 ,  1.4913936 , -4.4562883 ,  0.41522864,
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        0.4778607 , -1.0830758 ,  0.35304537,  3.4499156 , -0.87768006,
       -1.7307644 , -2.1884813 ,  0.43678772, -1.930743  , -0.01813772,
        3.718098  , -0.53959894, -1.335005  ,  0.27269697, -5.0354595 ,
       -0.16467714,  1.1458626 , -1.7335804 ,  0.1626569 ,  2.7505531 ,
        0.11621028,  1.2821062 , -0.19435205, -2.8234613 ,  4.1511164 ,
       -2.4757557 ,  0.03840414,  0.0432989 , -0.3007772 , -1.5862741 ,
        1.0559435 , -0.6310524 , -2.5236807 , -1.2584276 , -1.8849669 ,
        1.2976154 , -0.8304628 , -1.4791582 , -1.861482  , -1.0274534 ,
        0.6839042 , -1.0360558 ,  0.8202561 , -1.1161385 ,  7.7910476 ,
       -1.3407054 ,  1.3655416 ,  3.787745  , -1.1106999 , -3.5955493 ,
        2.9236133 ], dtype=float32))
96
(in, array([ 1.5729948 ,  0.7450902 ,  0.8069773 ,  0.74775606,  0.27672353,
       -1.8811946 ,  0.33814797, -1.8772222 ,  1.7758572 ,  1.275269  ,
        0.9736623 , -0.19324976, -1.951169  , -3.724183  , -0.41796422,
       -2.691314  ,  1.0998031 , -0.5248595 ,  1.9706867 ,  2.4800992 ,
        1.5852828 , -2.8402739 , -1.6020558 ,  0.31610787,  3.1018307 ,
        4.7706203 , -6.9525585 , -1.5816566 , -3.2872262 ,  3.043559  ,
       -0.31387913,  2.6139994 ,  0.810054  ,  1.8013479 , -1.1241221 ,
       -0.71740746,  0.7116769 , -2.4778075 , -1.48568   , -3.3040178 ,
       -0.6324476 ,  0.7465334 , -4.6861362 ,  0.97991335, -0.3077526 ,
        6.136875  , -0.84022987, -1.6332011 ,  1.0076431 , -3.4923897 ,
       -3.2357044 ,  1.353901  , -2.3551557 , -2.8896368 , -3.0143743 ,
        3.2872806 ,  4.22454   ,  0.816373  ,  3.9496846 , -0.78743875,
       -0.12611985,  5.444949  ,  2.2621984 ,  2.7974646 , -1.5514007 ,
        2.8991246 , -1.472271  ,  2.116822  , -2.20856   ,  1.9279625 ,
        0.26554292, -1.575736  ,  0.20392907, -2.7806053 , -1.8993406 ,
       -1.7426888 , -0.8765734 , -0.55309165, -0.48129553, -1.7858795 ,
        3.4534993 ,  0.7231988 ,  1.6344694 , -1.3028467 ,  0.7018702 ,
       -2.9955225 , -0.5727698 , -1.2353624 , -0.13237268,  0.7319336 ,
        0.6840315 ,  2.0993495 ,  0.08665347,  3.1888583 ,  0.5853627 ,
        1.8991051 ], dtype=float32))
96
(a, array([-3.3282251 , -1.3691131 , -2.934549  , -2.340916  ,  4.8183002 ,
       -2.202522  ,  1.8968023 , -3.0163288 ,  2.180525  ,  5.224683  ,
       -1.2434254 ,  4.5305896 ,  0.6607321 ,  1.5242531 , -1.1183844 ,
       -0.13869274,  0.90062445, -4.5529823 , -1.9707587 , -1.0051188 ,
        0.33559814, -3.5208926 , -2.0686502 ,  4.3486056 ,  7.796622  ,
        0.23985821, -2.5652092 , -0.5693804 , -2.1856968 , -0.21712303,
        2.2806444 , -2.9781034 , -0.5990461 ,  0.39138672, -1.327153  ,
        4.640827  ,  1.2833784 ,  0.45158553, -2.6282818 ,  2.251329  ,
       -2.320806  ,  0.5006534 ,  1.5637316 , -2.0096762 , -1.1137711 ,
        3.9609845 ,  0.74942696, -2.5477202 , -2.9577184 ,  0.69100946,
        0.3392086 , -0.3230876 , -2.7954376 , -3.550586  ,  1.2619126 ,
        1.577506  , -2.1533494 ,  1.9245732 ,  5.660588  , -3.8767962 ,
       -3.630488  ,  8.073983  ,  0.9395336 ,  3.7171106 , -2.3707552 ,
       -0.22747254,  1.9890454 ,  0.15459663,  1.7374067 , -4.3123074 ,
        4.4758883 , -0.6183425 ,  0.58390504,  1.8486688 ,  2.7558856 ,
       -0.7647184 , -1.8532819 ,  2.9707928 , -3.241314  ,  0.19559914,
       -0.57808965,  1.156788  , -0.37119734, -0.44435078, -1.7932878 ,
       -1.2846658 , -0.9373901 , -0.73694384,  3.5843186 , -0.9183064 ,
       -2.1538525 ,  1.3621731 , -2.3453588 ,  1.676705  ,  0.14406073,
       -0.68261296], dtype=float32))
96
(sentence, array([-2.541644  ,  1.5583074 , -0.34802747, -4.7855425 ,  2.6469998 ,
        2.6442323 , -1.1999503 ,  2.145074  , -0.94440514,  0.6636339 ,
        1.9116578 ,  3.5331104 , -1.4711996 ,  3.9577532 , -0.9526684 ,
       -2.2073083 , -1.2150416 , -2.2237704 , -1.5798779 ,  0.28367016,
        3.4588835 ,  0.6492324 , -0.9858179 ,  4.6781225 , -0.50881094,
        0.13094723, -0.11013544,  2.7614663 , -3.0787354 , -1.2680598 ,
        0.29348797, -2.329422  ,  2.6089275 , -2.1406054 ,  1.6745391 ,
       -2.434673  , -1.1006545 ,  1.7030747 , -2.15863   , -1.5375987 ,
        0.8271664 ,  1.5595732 , -3.5920107 ,  1.6792246 ,  0.03336939,
       -1.8735105 ,  1.1161293 , -1.1950973 , -2.7358866 , -1.6816171 ,
        0.19237933, -0.10252789,  1.3550694 , -1.636153  , -1.6383893 ,
        2.676569  , -1.1655024 ,  2.895232  ,  7.916453  , -1.4031966 ,
        0.4070539 ,  2.7138362 ,  2.1781225 , -0.46398705, -0.12336171,
       -2.5229006 , -0.34368637,  2.0417006 , -0.6189418 , -2.2369466 ,
```

```
        -2.003452  , -1.5565082 ,  1.0450965 ,  1.0427415 ,  4.883109  ,
        -3.0755491 ,  2.4713068 , -0.54625785,  0.07397544, -1.9196332 ,
         2.3931663 ,  3.0507267 , -1.2716902 ,  1.1580043 , -1.1768163 ,
        -1.080756  , -1.1908052 , -0.7764472 ,  1.1660949 ,  3.4331353 ,
        -1.448225  , -1.1196027 , -1.3886498 , -1.6034784 , -0.98014784,
         0.5070282 ], dtype=float32))
96
```

8.4 Tfidf-W2V of training data

In [22]:

```python
glove = spacy.load('en_core_web_sm')

X_train_question1_TfidfW2V = []

for row in tqdm(list(df_train['question1'].values)):
    doc1 = glove(row)        # it will return <class spacy.tokens.doc.Doc> which inclues word and it
s vector representation

    tfidf_vec = np.zeros((len(doc1), len(doc1[0].vector)))    # it returns the shape of length of th
e question we have(len(df_train['question1'].iloc[0])),  shape of vector representation of each wo
rd)
    for word in doc1:
        vec1 = word.vector

        try:
            idf = word2tfidf[str(word)]     # we are getting the idf value of word from word2tfidf w
hich we found before

        except:
            idf = 0                        # if there is no such word found in word2tfidf put idf =


        tfidf_vec += vec1 * idf
    tfidf_vec = tfidf_vec.mean(axis=0)
    X_train_question1_TfidfW2V.append(tfidf_vec/sum_idf)


# For question2
X_train_question2_TfidfW2V = []
for row in tqdm(df_train['question2'].values):
    doc1 = glove(row)

    tfidf_vec = np.zeros((len(doc1), len(doc1[0].vector)))
    for word in doc1:
        vec1 = word.vector

        try:
            idf = word2tfidf[str(word)]

        except:
            idf = 0

        tfidf_vec += vec1 * idf
    tfidf_vec = tfidf_vec.mean(axis=0)
    X_train_question2_TfidfW2V.append(tfidf_vec/sum_idf)
```

```
100%|██████████| 198102/198102 [22:27<00:00, 147.05it/s]
100%|██████████| 198102/198102 [22:21<00:00, 147.72it/s]
```

In [23]:

```python
(pd.DataFrame(list(X_train_question1_TfidfW2V), index=df_train.index)).head()
```

Out[23]:

	0	1	2	3	4	5	6	7	8	9	...	86	87	
209577	-0.001408	0.000327	0.000356	-0.000416	0.001152	-0.000225	0.001099	0.000287	-0.000768	0.000180	...	-0.000187	-0.001495	0.
17392	-[illegible]	0.000516	-[illegible]	0.000124	0.000089	-[illegible]	0.000848	0.000239	-[illegible]	-[illegible]	...	0.000256	-[illegible]	[illegible]

	0	1	2	3	4	5	6	7	8	9	...	86	87	
	0.000344		0.000370			0.000218			0.000233	0.000029			0.000107	0.
14251	0.000334	-0.000510	-0.000159	-0.000220	0.000479	0.000201	0.000521	0.000392	-0.000214	-0.000038	...	0.000050	-0.000384	0.
265830	0.000964	-0.000363	-0.000142	-0.001105	0.000086	0.000750	0.002265	-0.000686	-0.001093	0.002652	...	-0.000203	-0.000720	0.
123216	0.000499	0.000644	0.000045	-0.000645	-0.000056	0.000088	0.000884	0.000917	0.000086	0.000066	...	0.000612	-0.001536	0.

5 rows × 96 columns

In [24]:

```
#creating a new_df and store the values pf X_train_question1_TfidfW2V, X_train_question2_TfidfW2V
df1_train_q1 = pd.DataFrame(list(X_train_question1_TfidfW2V), index=df_train.index)
df1_train_q2 = pd.DataFrame(list(X_train_question2_TfidfW2V), index=df_train.index)
df1_train_q1['id'] = df_train['id']
df1_train_q2['id'] = df_train['id']
```

In [25]:

```
df1_train_q1.head()
```

Out[25]:

	0	1	2	3	4	5	6	7	8	9	...	87	88	
209577	-0.001408	0.000327	0.000356	-0.000416	0.001152	-0.000225	0.001099	0.000287	-0.000768	0.000180	...	-0.001495	-0.000674	0.
17392	-0.000344	0.000516	-0.000370	0.000124	0.000089	-0.000218	0.000848	0.000239	-0.000233	-0.000029	...	-0.000107	-0.000330	0.
14251	0.000334	-0.000510	-0.000159	-0.000220	0.000479	0.000201	0.000521	0.000392	-0.000214	-0.000038	...	-0.000384	0.000271	0.
265830	0.000964	-0.000363	-0.000142	-0.001105	0.000086	0.000750	0.002265	-0.000686	-0.001093	0.002652	...	-0.000720	-0.000117	0.
123216	0.000499	0.000644	0.000045	-0.000645	-0.000056	0.000088	0.000884	0.000917	0.000086	0.000066	...	-0.001536	-0.000459	0.

5 rows × 97 columns

In [26]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/df1_train_q1', 'wb') as f:
    pickle.dump(df1_train_q1, f)
```

In [27]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/df1_train_q2', 'wb') as f:
    pickle.dump(df1_train_q2, f)
```

8.4 Tfidf-W2V of Validation data

In [28]:

```
X_val_question1_TfidfW2V = []

for row in tqdm(df_val['question1'].values):
    doc1 = glove(row)

    tfidf_vec = np.zeros((len(doc1), len(doc1[0].vector)))
    for word in doc1:
        vec1 = word.vector

        try:
            idf = word2tfidf[str(word)]

        except:
```

```
        except:
            idf = 0

        tfidf_vec += vec1*idf
    tfidf_vec = tfidf_vec.mean(axis=0)
    X_val_question1_TfidfW2V.append(tfidf_vec/sum_idf)


#for question2
X_val_question2_TfidfW2V = []

for row in tqdm(df_val['question2'].values):
    doc1 = glove(row)

    tfidf_vec = np.zeros((len(doc1), len(doc1[0].vector)))
    for word in doc1:
        vec1 = word.vector

        try:
            idf = word2tfidf[str(word)]

        except:
            idf = 0

        tfidf_vec += vec1*idf
    tfidf_vec = tfidf_vec.mean(axis=0)
    X_val_question2_TfidfW2V.append(tfidf_vec/sum_idf)
```

```
100%|██████████| 121287/121287 [13:41<00:00, 147.68it/s]
100%|██████████| 121287/121287 [13:41<00:00, 147.69it/s]
```

In [0]:

```
#df_val['q1_feat_m'] = list(X_val_question1_TfidfW2V)
#df_val['q2_feat_m'] = list(X_val_question2_TfidfW2V)
```

In [29]:

```
#creating a new_df and store the values pf X_train_question1_TfidfW2V, X_train_question2_TfidfW2V
df1_val_q1 = pd.DataFrame(list(X_val_question1_TfidfW2V), index=df_val.index)
df1_val_q2 = pd.DataFrame(list(X_val_question2_TfidfW2V), index=df_val.index)

df1_val_q1['id'] = df_val['id']
df1_val_q2['id'] = df_val['id']
```

In [30]:

```
df1_val_q1.head()
```

Out[30]:

	0	1	2	3	4	5	6	7	8	9	...	87	88	
40373	-0.000159	0.000458	-0.000402	-0.000483	0.000130	-0.000119	0.001170	0.001561	-0.000635	-0.000450	...	-0.000481	-0.000330	0.
218089	0.000898	-0.000156	-0.000911	-0.000556	-0.000303	0.000870	0.001503	0.002291	0.000382	-0.001005	...	-0.001964	0.000057	0.
184729	0.000133	0.000457	-0.000055	-0.000310	0.000429	-0.000365	0.000877	0.001336	0.000402	-0.000686	...	-0.000902	-0.000764	0.
218907	-0.000462	0.002448	0.001263	-0.001688	0.002052	-0.001278	0.001801	0.000822	0.000178	-0.000191	...	-0.003103	-0.002005	0.
224215	-0.000054	0.000435	-0.000574	-0.000348	0.001170	0.000409	0.001567	0.001446	0.001041	0.000295	...	-0.001201	-0.000728	0.

5 rows × 97 columns

In [31]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/df1_val_q1', 'wb') as f:
    pickle.dump(df1_val_q1, f)
```

```
    pickle.dump(df1_val_q1, f)
```

In [32]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/df1_val_q2', 'wb') as f:
    pickle.dump(df1_val_q2, f)
```

8.5 Tfidf-W2V of test data

In [33]:

```
X_test_question1_TfidfW2V = []

for row in tqdm(df_test['question1'].values):
    doc1 = glove(row)

    tfidf_vec = np.zeros((len(doc1), len(doc1[0].vector)))
    for word in doc1:
        vec1 = word.vector

        try:
            idf = word2tfidf[str(word)]

        except:
            idf = 0

        tfidf_vec += vec1*idf
    tfidf_vec = tfidf_vec.mean(axis=0)
    X_test_question1_TfidfW2V.append(tfidf_vec/sum_idf)


#for question2
X_test_question2_TfidfW2V = []

for row in tqdm(df_test['question2'].values):
    doc1 = glove(row)

    tfidf_vec = np.zeros((len(doc1), len(doc1[0].vector)))
    for word in doc1:
        vec1 = word.vector

        try:
            idf = word2tfidf[str(word)]

        except:
            idf = 0

        tfidf_vec += vec1*idf
    tfidf_vec = tfidf_vec.mean(axis=0)
    X_test_question2_TfidfW2V.append(tfidf_vec/sum_idf)
```

```
100%|██████████| 84901/84901 [09:40<00:00, 146.15it/s]
100%|██████████| 84901/84901 [09:38<00:00, 146.78it/s]
```

In [0]:

```
#df_test['q1_feat_m'] = list(X_test_question1_TfidfW2V)
#df_test['q2_feat_m'] = list(X_test_question2_TfidfW2V)
```

In [34]:

```
#creating a new_df and store the values pf X_test_question1_TfidfW2V, X_test_question2_TfidfW2V
df1_test_q1 = pd.DataFrame(list(X_test_question1_TfidfW2V), index=df_test.index)
df1_test_q2 = pd.DataFrame(list(X_test_question2_TfidfW2V), index=df_test.index)

df1_test_q1['id'] = df_test['id']
df1_test_q2['id'] = df_test['id']
```

In [35]:

```python
df1_test_q1.head()
```

Out[35]:

	0	1	2	3	4	5	6	7	8	9	...	87	88
372980	-0.000377	0.001172	-0.000138	-4.555279e-04	0.000465	-0.001193	0.001572	-0.000303	0.000256	0.000120	...	-0.001498	-0.000906
14252	-0.000528	0.002283	0.001105	-4.036084e-04	0.000775	-0.000185	0.000425	0.001776	-0.000436	-0.000561	...	-0.000986	-0.001245
102303	0.000677	0.001573	-0.000833	-9.117768e-07	0.000431	0.000549	-0.000038	0.001381	-0.000317	-0.001411	...	-0.002414	-0.000285
274316	0.000050	0.000015	0.000009	-1.674369e-05	0.000129	-0.000316	0.000146	0.000182	0.000002	-0.000020	...	-0.000116	0.000231
370597	-0.000573	0.000716	-0.000578	-3.668037e-04	0.000186	0.000074	0.001728	0.000995	-0.000444	0.000115	...	-0.001228	-0.000281

5 rows × 97 columns

In [36]:

```python
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/df1_test_q1', 'wb') as f:
    pickle.dump(df1_test_q1, f)
```

In [37]:

```python
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/df1_test_q2', 'wb') as f:
    pickle.dump(df1_test_q2, f)
```

In [39]:

```python
print(df1_train_q1.shape)
print(df1_train_q2.shape)
print(df1_val_q1.shape)
print(df1_val_q2.shape)
print(df1_test_q1.shape)
print(df1_test_q2.shape)
print(y_train.shape)
print(y_val.shape)
print(y_test.shape)
```

```
(198102, 97)
(198102, 97)
(121287, 97)
(121287, 97)
(84901, 97)
(84901, 97)
(198102, 1)
(121287, 1)
(84901, 1)
```

8.6 Adding all the features to make the final dataframe

- df1 ==>tfidf_w2v_q1, tfidf_w2v_q2
- df2 ==> df_fe_without_preprocessing
- df3 ==>nlp_preprocessed

8.6.1 df_fe_without_preprocessing

In [38]:

```
# 1. importing the df_fe_without_preprocessing
df2 = pd.read_csv('df_fe_without_preprocessing_train.csv', encoding='latin-1')
df2.head()
```

Out[38]:

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common
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	66	57	14	12	10.0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	4	1	51	88	8	13	4.0
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0	1	1	73	59	14	10	4.0
3	3	7	8	Why am I mentally very lonely? How can I solve...	Find the remainder when [math]23^{24}[/math] i...	0	1	1	50	65	11	9	0.0
4	4	9	10	Which one dissolve in water quikly sugar, salt...	Which fish would survive in salt water?	0	3	1	76	39	13	7	2.0

In [40]:

```
df2.drop(labels=['qid1', 'qid2', 'question1', 'question2'], axis=1, inplace=True)
df2.head()
```

Out[40]:

	id	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	word_share	freq_q1+q2
0	0	0	1	1	66	57	14	12	10.0	23.0	0.434783	2
1	1	0	4	1	51	88	8	13	4.0	20.0	0.200000	5
2	2	0	1	1	73	59	14	10	4.0	24.0	0.166667	2
3	3	0	1	1	50	65	11	9	0.0	19.0	0.000000	2
4	4	0	3	1	76	39	13	7	2.0	20.0	0.100000	4

In [41]:

```
#Splitting it
df2_train, df2_val, y_train, y_val = train_test_split(df2, df.iloc[:, -1:], test_size=0.3, random_s
tate=0, stratify = df.iloc[:,-1:])
df2_train, df2_test, y_train, y_test = train_test_split(df2_train, y_train, test_size=0.3, random_s
tate=0, stratify = y_train)
```

In [42]:

```
print(df2_train.shape)
print(df2_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(198102, 13)
(84901, 13)
(198102, 1)
(84901, 1)
```

In [43]:

```
df2_train.head()
```

Out[43]:

	id	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	word_share	fr
209577	209577	0	4	2	75	46	16	10	8.0	24.0	0.333333	
17392	17392	1	1	1	29	33	5	6	4.0	11.0	0.363636	
14251	14251	0	1	1	58	38	7	6	5.0	13.0	0.384615	
265830	265830	0	1	5	124	136	20	24	5.0	42.0	0.119048	
123216	123216	1	1	1	51	51	8	8	7.0	16.0	0.437500	

8.6.2 NLP_features

In [47]:

```
# 2. importing nlp_features
df3 = pd.read_csv('nlp_features_train.csv', encoding='latin-1')
df3.head()
```

Out[47]:

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	...	ctc_max	last_word_eq	first_word_
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	0.999980	0.833319	0.999983	0.999983	...	0.785709	0.0	
1	1	3	4	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0	0.799984	0.399996	0.749981	0.599988	...	0.466664	0.0	
2	2	5	6	how can i increase the speed of my internet co...	how can internet speed be increased by hacking...	0	0.399992	0.333328	0.399992	0.249997	...	0.285712	0.0	
3	3	7	8	why am i mentally very lonely how can i solve...	find the remainder when math 23 24 math i...	0	0.000000	0.000000	0.000000	0.000000	...	0.000000	0.0	
4	4	9	10	which one dissolve in water quikly sugar salt...	which fish would survive in salt water	0	0.399992	0.199998	0.999950	0.666644	...	0.307690	0.0	

5 rows × 21 columns

In [48]:

```
df3.drop(labels=['qid1', 'qid2', 'question1', 'question2', 'is_duplicate'], axis=1, inplace=True)
df3.head()
```

Out[48]:

	id	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_rati
0	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	1.0	2.0	13.0	1(
1	1	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	5.0	12.5	ε
2	2	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	4.0	12.0	6
3	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	2.0	12.0	3
4	4	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	1.0	6.0	10.0	6

In [49]:

```
#Splitting it
df3_train, df3_val, y_train, y_val = train_test_split(df3, df.iloc[:, -1:], test_size=0.3, random_s
tate=0, stratify=df.iloc[:, -1:])
df3_train, df3_test, y_train, y_test = train_test_split(df3_train, y_train, test_size=0.3, random_s
tate=0, stratify=y_train)
```

In [50]:

```
print(df3_train.shape)
print(df3_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(198102, 16)
(84901, 16)
(198102, 1)
(84901, 1)
```

In [51]:

```
df3_train.head()
```

Out[51]:

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len	tok
209577	209577	0.999967	0.599988	0.999986	0.777769	0.999990	0.624996	1.0	1.0	6.0	13.0	
17392	17392	0.999967	0.999967	0.499975	0.333322	0.799984	0.666656	1.0	0.0	1.0	5.5	
14251	14251	0.666644	0.499988	0.999967	0.999967	0.833319	0.714276	0.0	1.0	1.0	6.5	
265830	265830	0.272725	0.249998	0.249997	0.199998	0.249999	0.208332	0.0	0.0	4.0	22.0	
123216	123216	0.999967	0.999967	0.799984	0.799984	0.874989	0.874989	1.0	1.0	0.0	8.0	

8.7 Merging all the features to make it one

In [52]:

```
df1_train_q1.head()
```

Out[52]:

	0	1	2	3	4	5	6	7	8	9	...	87	88	
209577	-0.001408	0.000327	0.000356	-0.000416	0.001152	-0.000225	0.001099	0.000287	-0.000768	0.000180	...	-0.001495	-0.000674	0.
17392	-0.000344	0.000516	-0.000370	0.000124	0.000089	-0.000218	0.000848	0.000239	-0.000233	-0.000029	...	-0.000107	-0.000330	0.
14251	0.000334	-0.000510	-0.000159	-0.000220	0.000479	0.000201	0.000521	0.000392	-0.000214	-0.000038	...	-0.000384	0.000271	0.
265830	0.000964	-0.000363	-0.000142	-0.001105	0.000086	0.000750	0.002265	-0.000686	-0.001093	0.002652	...	-0.000720	-0.000117	0.
123216	0.000499	0.000644	0.000045	-0.000645	-0.000056	0.000088	0.000884	0.000917	0.000086	0.000066	...	-0.001536	-0.000459	0.

5 rows × 97 columns

In [53]:

```
df1_train_q2.head()
```

Out[53]:

	0	1	2	3	4	5	6	7	8	9	...	87	88	
209577	-0.000420	0.000732	0.000223	0.000098	0.000457	-0.000188	0.000593	0.000071	-0.000114	-0.000216	...	-0.001276	-0.000195	0.
17392	-0.000241	0.000540	-0.000648	-0.000138	-0.000073	-0.000196	0.000974	0.000221	-0.000201	0.000083	...	-0.000613	-0.000766	0.
14251	0.000454	-0.000384	-0.000364	-0.000215	0.000243	-0.000016	0.000652	0.000399	-0.000200	-0.000213	...	-0.000569	0.000327	0.
265830	0.000921	0.001301	-0.001152	-0.002585	0.001618	-0.000932	0.001984	0.001619	0.000762	0.000165	...	-0.001595	-0.001627	0.
123216	0.000330	0.000452	-0.000152	-0.000489	-0.000366	0.000410	0.000901	0.000759	0.000181	0.000383	...	-0.001200	-0.000771	0.

5 rows × 97 columns

In [54]:

```
df2_train.head()
```

Out[54]:

	id	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	word_share	fi
209577	209577	0	4	2	75	46	16	10	8.0	24.0	0.333333	
17392	17392	1	1	1	29	33	5	6	4.0	11.0	0.363636	
14251	14251	0	1	1	58	38	7	6	5.0	13.0	0.384615	
265830	265830	0	1	5	124	136	20	24	5.0	42.0	0.119048	
123216	123216	1	1	1	51	51	8	8	7.0	16.0	0.437500	

In [44]:

```
df3_train.head()
```

Out[44]:

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len	tok
209577	209577	0.999967	0.599988	0.999986	0.777769	0.999990	0.624996	1.0	1.0	6.0	13.0	
17392	17392	0.999967	0.999967	0.499975	0.333322	0.799984	0.666656	1.0	0.0	1.0	5.5	
14251	14251	0.666644	0.499988	0.999967	0.999967	0.833319	0.714276	0.0	1.0	1.0	6.5	
265830	265830	0.272725	0.249998	0.249997	0.199998	0.249999	0.208332	0.0	0.0	4.0	22.0	
123216	123216	0.999967	0.999967	0.799984	0.799984	0.874989	0.874989	1.0	1.0	0.0	8.0	

In [55]:

```
#merging all by id
df3_train = df3_train.merge(df2_train, on='id', how='left')
df3_train = df3_train.merge(df1_train_q1, on='id', how='left')
result_train = df3_train.merge(df1_train_q2, on='id', how='left')

df3_val = df3_val.merge(df2_val, on='id', how='left')
df3_val = df3_val.merge(df1_val_q1, on='id', how='left')
result_val = df3_val.merge(df1_val_q2, on='id', how='left')
```

```
df3_test = df3_test.merge(df2_test, on='id', how='left')
df3_test = df3_test.merge(df1_test_q1, on='id', how='left')
result_test = df3_test.merge(df1_test_q2, on='id', how='left')
```

In [56]:

```
result_train.head()
```

Out[56]:

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	...	86_y	87
0	209577	0.999967	0.599988	0.999986	0.777769	0.999990	0.624996	1.0	1.0	6.0	...	0.000075	0.0012
1	17392	0.999967	0.999967	0.499975	0.333322	0.799984	0.666656	1.0	0.0	1.0	...	0.000448	0.0006
2	14251	0.666644	0.499988	0.999967	0.999967	0.833319	0.714276	0.0	1.0	1.0	...	0.000174	0.0005
3	265830	0.272725	0.249998	0.249997	0.199998	0.249999	0.208332	0.0	0.0	4.0	...	0.000124	0.0015
4	123216	0.999967	0.999967	0.799984	0.799984	0.874989	0.874989	1.0	1.0	0.0	...	0.000776	0.0012

5 rows × 220 columns

In [57]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/final_features_train', 'wb') as f:
    pickle.dump(result_train, f)
```

In [58]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/final_features_val', 'wb') as f:
    pickle.dump(result_val, f)
```

In [59]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/final_features_test', 'wb') as f:
    pickle.dump(result_test, f)
```

9. Saving it in sqlite db

- Since i have already finished the assignment of stackoverflow tag predictor and i worked with sqlite db there, i am here just saving it in db and i will only use the above final_features_train.csv, final_features_val.csv and final_features_test.csv

In [0]:

```
#creating train db using final_feature_train and storing those values in train_data table
if not os.path.isfile('train.db'):
    disk_engine = create_engine('sqlite:///train.db')
    start = datetime.datetime.now()
    chunk_size = 180000
    j = 0
    index_start = 1

    for df in pd.read_csv('final_features_train.csv', names=['Unnamed: 0','id','is_duplicate','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','freq_qid1','freq_qid2','q1len','q2len','q1_n_words','q2_n_words','word_Common','word_Total
','word_share','freq_q1+q2','freq_q1-
q2','0_x','1_x','2_x','3_x','4_x','5_x','6_x','7_x','8_x','9_x','10_x','11_x','12_x','13_x','14_x',
'15_x','16_x','17_x','18_x','19_x','20_x','21_x','22_x','23_x','24_x','25_x','26_x','27_x','28_x','
29_x','30_x','31_x','32_x','33_x','34_x','35_x','36_x','37_x','38_x','39_x','40_x','41_x','42_x','4
```

```
3_x','44_x','45_x','46_x','47_x','48_x','49_x','50_x','51_x','52_x','53_x','54_x','55_x','56_x','57
_x','58_x','59_x','60_x','61_x','62_x','63_x','64_x','65_x','66_x','67_x','68_x','69_x','70_x','71_
x','72_x','73_x','74_x','75_x','76_x','77_x','78_x','79_x','80_x','81_x','82_x','83_x','84_x','85_x
','86_x','87_x','88_x','89_x','90_x','91_x','92_x','93_x','94_x','95_x','96_x','97_x','98_x','99_x'
,'100_x','101_x','102_x','103_x','104_x','105_x','106_x','107_x','108_x','109_x','110_x','111_x','
112_x','113_x','114_x','115_x','116_x','117_x','118_x','119_x','120_x','121_x','122_x','123_x','12
4_x','125_x','126_x','127_x','128_x','129_x','130_x','131_x','132_x','133_x','134_x','135_x','136_
x','137_x','138_x','139_x','140_x','141_x','142_x','143_x','144_x','145_x','146_x','147_x','148_x'
,'149_x','150_x','151_x','152_x','153_x','154_x','155_x','156_x','157_x','158_x','159_x','160_x','
161_x','162_x','163_x','164_x','165_x','166_x','167_x','168_x','169_x','170_x','171_x','172_x','17
3_x','174_x','175_x','176_x','177_x','178_x','179_x','180_x','181_x','182_x','183_x','184_x','185_
x','186_x','187_x','188_x','189_x','190_x','191_x','192_x','193_x','194_x','195_x','196_x','197_x'
,'198_x','199_x','200_x','201_x','202_x','203_x','204_x','205_x','206_x','207_x','208_x','209_x','
210_x','211_x','212_x','213_x','214_x','215_x','216_x','217_x','218_x','219_x','220_x','221_x','22
2_x','223_x','224_x','225_x','226_x','227_x','228_x','229_x','230_x','231_x','232_x','233_x','234_
x','235_x','236_x','237_x','238_x','239_x','240_x','241_x','242_x','243_x','244_x','245_x','246_x'
,'247_x','248_x','249_x','250_x','251_x','252_x','253_x','254_x','255_x','256_x','257_x','258_x','
259_x','260_x','261_x','262_x','263_x','264_x','265_x','266_x','267_x','268_x','269_x','270_x','27
1_x','272_x','273_x','274_x','275_x','276_x','277_x','278_x','279_x','280_x','281_x','282_x','283_
x','284_x','285_x','286_x','287_x','288_x','289_x','290_x','291_x','292_x','293_x','294_x','295_x'
,'296_x','297_x','298_x','299_x','300_x','301_x','302_x','303_x','304_x','305_x','306_x','307_x','
308_x','309_x','310_x','311_x','312_x','313_x','314_x','315_x','316_x','317_x','318_x','319_x','32
0_x','321_x','322_x','323_x','324_x','325_x','326_x','327_x','328_x','329_x','330_x','331_x','332_
x','333_x','334_x','335_x','336_x','337_x','338_x','339_x','340_x','341_x','342_x','343_x','344_x'
,'345_x','346_x','347_x','348_x','349_x','350_x','351_x','352_x','353_x','354_x','355_x','356_x','
357_x','358_x','359_x','360_x','361_x','362_x','363_x','364_x','365_x','366_x','367_x','368_x','36
9_x','370_x','371_x','372_x','373_x','374_x','375_x','376_x','377_x','378_x','379_x','380_x','381_
x','382_x','383_x','0_y','1_y','2_y','3_y','4_y','5_y','6_y','7_y','8_y','9_y','10_y','11_y','12_y'
,'13_y','14_y','15_y','16_y','17_y','18_y','19_y','20_y','21_y','22_y','23_y','24_y','25_y','26_y',
'27_y','28_y','29_y','30_y','31_y','32_y','33_y','34_y','35_y','36_y','37_y','38_y','39_y','40_y','
41_y','42_y','43_y','44_y','45_y','46_y','47_y','48_y','49_y','50_y','51_y','52_y','53_y','54_y','5
5_y','56_y','57_y','58_y','59_y','60_y','61_y','62_y','63_y','64_y','65_y','66_y','67_y','68_y','69
_y','70_y','71_y','72_y','73_y','74_y','75_y','76_y','77_y','78_y','79_y','80_y','81_y','82_y','83_
y','84_y','85_y','86_y','87_y','88_y','89_y','90_y','91_y','92_y','93_y','94_y','95_y','96_y','97_y
','98_y','99_y','100_y','101_y','102_y','103_y','104_y','105_y','106_y','107_y','108_y','109_y','11
0_y','111_y','112_y','113_y','114_y','115_y','116_y','117_y','118_y','119_y','120_y','121_y','122_
y','123_y','124_y','125_y','126_y','127_y','128_y','129_y','130_y','131_y','132_y','133_y','134_y'
,'135_y','136_y','137_y','138_y','139_y','140_y','141_y','142_y','143_y','144_y','145_y','146_y','
147_y','148_y','149_y','150_y','151_y','152_y','153_y','154_y','155_y','156_y','157_y','158_y','15
9_y','160_y','161_y','162_y','163_y','164_y','165_y','166_y','167_y','168_y','169_y','170_y','171_
y','172_y','173_y','174_y','175_y','176_y','177_y','178_y','179_y','180_y','181_y','182_y','183_y'
,'184_y','185_y','186_y','187_y','188_y','189_y','190_y','191_y','192_y','193_y','194_y','195_y','
196_y','197_y','198_y','199_y','200_y','201_y','202_y','203_y','204_y','205_y','206_y','207_y','20
8_y','209_y','210_y','211_y','212_y','213_y','214_y','215_y','216_y','217_y','218_y','219_y','220_
y','221_y','222_y','223_y','224_y','225_y','226_y','227_y','228_y','229_y','230_y','231_y','232_y'
,'233_y','234_y','235_y','236_y','237_y','238_y','239_y','240_y','241_y','242_y','243_y','244_y','
245_y','246_y','247_y','248_y','249_y','250_y','251_y','252_y','253_y','254_y','255_y','256_y','25
7_y','258_y','259_y','260_y','261_y','262_y','263_y','264_y','265_y','266_y','267_y','268_y','269_
y','270_y','271_y','272_y','273_y','274_y','275_y','276_y','277_y','278_y','279_y','280_y','281_y'
,'282_y','283_y','284_y','285_y','286_y','287_y','288_y','289_y','290_y','291_y','292_y','293_y','
294_y','295_y','296_y','297_y','298_y','299_y','300_y','301_y','302_y','303_y','304_y','305_y','30
6_y','307_y','308_y','309_y','310_y','311_y','312_y','313_y','314_y','315_y','316_y','317_y','318_
y','319_y','320_y','321_y','322_y','323_y','324_y','325_y','326_y','327_y','328_y','329_y','330_y'
,'331_y','332_y','333_y','334_y','335_y','336_y','337_y','338_y','339_y','340_y','341_y','342_y','
343_y','344_y','345_y','346_y','347_y','348_y','349_y','350_y','351_y','352_y','353_y','354_y','35
5_y','356_y','357_y','358_y','359_y','360_y','361_y','362_y','363_y','364_y','365_y','366_y','367_
y','368_y','369_y','370_y','371_y','372_y','373_y','374_y','375_y','376_y','377_y','378_y','379_y'
,'380_y','381_y','382_y','383_y'], chunksize=chunksize, iterator=True, encoding='utf-8'):
        df.index += index_start
        j += 1
        print('{} rows'.format(j*chunksize))
        df.tosql('train_data', disk_engine, if_exists='append')
        index_start = df.index[-1]+1
```

In [0]:

```
#creating val db using final_feature_val and storing thoswe values in val_data table
if not os.path.isfile('val.db'):
    disk_engine = create_engine('sqlite:///val.db')
    start = datetime.datetime.now()
    chunk_size = 180000
    j = 0
    index_start = 1

    for df in pd.read_csv('final_features_val.csv', names=['Unnamed: 0','id','is_duplicate','cwc_mi
n','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','freq_qid1','freq_qid2','q1len','q2len','q1_n_words','q2_n_words','word_Common','word_Total'
,'word_share','freq_q1+q2','freq_q1-
q2','0_x','1_x','2_x','3_x','4_x','5_x','6_x','7_x','8_x','9_x','10_x','11_x','12_x','13_x','14_x',
'15_x','16_x','17_x','18_x','19_x','20_x','21_x','22_x','23_x','24_x','25_x','26_x','27_x','28_x','
29_x','30_x','31_x','32_x','33_x','34_x','35_x','36_x','37_x','38_x','39_x','40_x','41_x','42_x','4
3_x','44_x','45_x','46_x','47_x','48_x','49_x','50_x','51_x','52_x','53_x','54_x','55_x','56_x','57
_x','58_x','59_x','60_x','61_x','62_x','63_x','64_x','65_x','66_x','67_x','68_x','69_x','70_x','71_
x','72_x','73_x','74_x','75_x','76_x','77_x','78_x','79_x','80_x','81_x','82_x','83_x','84_x','85_x
','86_x','87_x','88_x','89_x','90_x','91_x','92_x','93_x','94_x','95_x','96_x','97_x','98_x','99_x'
,'100_x','101_x','102_x','103_x','104_x','105_x','106_x','107_x','108_x','109_x','110_x','111_x','
112_x','113_x','114_x','115_x','116_x','117_x','118_x','119_x','120_x','121_x','122_x','123_x','12
4_x','125_x','126_x','127_x','128_x','129_x','130_x','131_x','132_x','133_x','134_x','135_x','136_
x','137_x','138_x','139_x','140_x','141_x','142_x','143_x','144_x','145_x','146_x','147_x','148_x'
,'149_x','150_x','151_x','152_x','153_x','154_x','155_x','156_x','157_x','158_x','159_x','160_x','
161_x','162_x','163_x','164_x','165_x','166_x','167_x','168_x','169_x','170_x','171_x','172_x','17
3_x','174_x','175_x','176_x','177_x','178_x','179_x','180_x','181_x','182_x','183_x','184_x','185_
x','186_x','187_x','188_x','189_x','190_x','191_x','192_x','193_x','194_x','195_x','196_x','197_x'
,'198_x','199_x','200_x','201_x','202_x','203_x','204_x','205_x','206_x','207_x','208_x','209_x','
210_x','211_x','212_x','213_x','214_x','215_x','216_x','217_x','218_x','219_x','220_x','221_x','22
2_x','223_x','224_x','225_x','226_x','227_x','228_x','229_x','230_x','231_x','232_x','233_x','234_
x','235_x','236_x','237_x','238_x','239_x','240_x','241_x','242_x','243_x','244_x','245_x','246_x'
,'247_x','248_x','249_x','250_x','251_x','252_x','253_x','254_x','255_x','256_x','257_x','258_x','
259_x','260_x','261_x','262_x','263_x','264_x','265_x','266_x','267_x','268_x','269_x','270_x','27
1_x','272_x','273_x','274_x','275_x','276_x','277_x','278_x','279_x','280_x','281_x','282_x','283_
x','284_x','285_x','286_x','287_x','288_x','289_x','290_x','291_x','292_x','293_x','294_x','295_x'
,'296_x','297_x','298_x','299_x','300_x','301_x','302_x','303_x','304_x','305_x','306_x','307_x','
308_x','309_x','310_x','311_x','312_x','313_x','314_x','315_x','316_x','317_x','318_x','319_x','32
0_x','321_x','322_x','323_x','324_x','325_x','326_x','327_x','328_x','329_x','330_x','331_x','332_
x','333_x','334_x','335_x','336_x','337_x','338_x','339_x','340_x','341_x','342_x','343_x','344_x'
,'345_x','346_x','347_x','348_x','349_x','350_x','351_x','352_x','353_x','354_x','355_x','356_x','
357_x','358_x','359_x','360_x','361_x','362_x','363_x','364_x','365_x','366_x','367_x','368_x','36
9_x','370_x','371_x','372_x','373_x','374_x','375_x','376_x','377_x','378_x','379_x','380_x','381_
x','382_x','383_x','0_y','1_y','2_y','3_y','4_y','5_y','6_y','7_y','8_y','9_y','10_y','11_y','12_y'
,'13_y','14_y','15_y','16_y','17_y','18_y','19_y','20_y','21_y','22_y','23_y','24_y','25_y','26_y',
'27_y','28_y','29_y','30_y','31_y','32_y','33_y','34_y','35_y','36_y','37_y','38_y','39_y','40_y','
41_y','42_y','43_y','44_y','45_y','46_y','47_y','48_y','49_y','50_y','51_y','52_y','53_y','54_y','5
5_y','56_y','57_y','58_y','59_y','60_y','61_y','62_y','63_y','64_y','65_y','66_y','67_y','68_y','69
_y','70_y','71_y','72_y','73_y','74_y','75_y','76_y','77_y','78_y','79_y','80_y','81_y','82_y','83_
y','84_y','85_y','86_y','87_y','88_y','89_y','90_y','91_y','92_y','93_y','94_y','95_y','96_y','97_y
','98_y','99_y','100_y','101_y','102_y','103_y','104_y','105_y','106_y','107_y','108_y','109_y','11
0_y','111_y','112_y','113_y','114_y','115_y','116_y','117_y','118_y','119_y','120_y','121_y','122_
y','123_y','124_y','125_y','126_y','127_y','128_y','129_y','130_y','131_y','132_y','133_y','134_y'
,'135_y','136_y','137_y','138_y','139_y','140_y','141_y','142_y','143_y','144_y','145_y','146_y','
147_y','148_y','149_y','150_y','151_y','152_y','153_y','154_y','155_y','156_y','157_y','158_y','15
9_y','160_y','161_y','162_y','163_y','164_y','165_y','166_y','167_y','168_y','169_y','170_y','171_
y','172_y','173_y','174_y','175_y','176_y','177_y','178_y','179_y','180_y','181_y','182_y','183_y'
,'184_y','185_y','186_y','187_y','188_y','189_y','190_y','191_y','192_y','193_y','194_y','195_y','
196_y','197_y','198_y','199_y','200_y','201_y','202_y','203_y','204_y','205_y','206_y','207_y','20
8_y','209_y','210_y','211_y','212_y','213_y','214_y','215_y','216_y','217_y','218_y','219_y','220_
y','221_y','222_y','223_y','224_y','225_y','226_y','227_y','228_y','229_y','230_y','231_y','232_y'
,'233_y','234_y','235_y','236_y','237_y','238_y','239_y','240_y','241_y','242_y','243_y','244_y','
245_y','246_y','247_y','248_y','249_y','250_y','251_y','252_y','253_y','254_y','255_y','256_y','25
7_y','258_y','259_y','260_y','261_y','262_y','263_y','264_y','265_y','266_y','267_y','268_y','269_
y','270_y','271_y','272_y','273_y','274_y','275_y','276_y','277_y','278_y','279_y','280_y','281_y'
,'282_y','283_y','284_y','285_y','286_y','287_y','288_y','289_y','290_y','291_y','292_y','293_y','
294_y','295_y','296_y','297_y','298_y','299_y','300_y','301_y','302_y','303_y','304_y','305_y','30
6_y','307_y','308_y','309_y','310_y','311_y','312_y','313_y','314_y','315_y','316_y','317_y','318_
y','319_y','320_y','321_y','322_y','323_y','324_y','325_y','326_y','327_y','328_y','329_y','330_y'
,'331_y','332_y','333_y','334_y','335_y','336_y','337_y','338_y','339_y','340_y','341_y','342_y','
343_y','344_y','345_y','346_y','347_y','348_y','349_y','350_y','351_y','352_y','353_y','354_y','35
5_y','356_y','357_y','358_y','359_y','360_y','361_y','362_y','363_y','364_y','365_y','366_y','367_
y','368_y','369_y','370_y','371_y','372_y','373_y','374_y','375_y','376_y','377_y','378_y','379_y'
,'380_y','381_y','382_y','383_y'], chunksize=chunksize, iterator=True, encoding='utf-8'):
        df.index += index_start
        j += 1
        print('{} rows'.format(j*chunksize))
        df.tosql('val_data', disk_engine, if_exists='append')
        index_start = df.index[-1]+1
```

In [0]:

```
#creating test db using final_feature_test and storing those values in test_data table
if not os.path.isfile('test.db'):
    disk_engine = create_engine('sqlite:///test.db')
    start = datetime.datetime.now()
```

```
    chunk_size = 180000
    j = 0
    index_start = 1

    for df in pd.read_csv('final_features_test.csv', names=['Unnamed: 0','id','is_duplicate','cwc_m
in','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','freq_qid1','freq_qid2','q1len','q2len','q1_n_words','q2_n_words','word_Common','word_Total'
,'word_share','freq_q1+q2','freq_q1-
q2','0_x','1_x','2_x','3_x','4_x','5_x','6_x','7_x','8_x','9_x','10_x','11_x','12_x','13_x','14_x',
'15_x','16_x','17_x','18_x','19_x','20_x','21_x','22_x','23_x','24_x','25_x','26_x','27_x','28_x','
29_x','30_x','31_x','32_x','33_x','34_x','35_x','36_x','37_x','38_x','39_x','40_x','41_x','42_x','4
3_x','44_x','45_x','46_x','47_x','48_x','49_x','50_x','51_x','52_x','53_x','54_x','55_x','56_x','57
_x','58_x','59_x','60_x','61_x','62_x','63_x','64_x','65_x','66_x','67_x','68_x','69_x','70_x','71_
x','72_x','73_x','74_x','75_x','76_x','77_x','78_x','79_x','80_x','81_x','82_x','83_x','84_x','85_x
','86_x','87_x','88_x','89_x','90_x','91_x','92_x','93_x','94_x','95_x','96_x','97_x','98_x','99_x'
,'100_x','101_x','102_x','103_x','104_x','105_x','106_x','107_x','108_x','109_x','110_x','111_x','
112_x','113_x','114_x','115_x','116_x','117_x','118_x','119_x','120_x','121_x','122_x','123_x','12
4_x','125_x','126_x','127_x','128_x','129_x','130_x','131_x','132_x','133_x','134_x','135_x','136_
x','137_x','138_x','139_x','140_x','141_x','142_x','143_x','144_x','145_x','146_x','147_x','148_x'
,'149_x','150_x','151_x','152_x','153_x','154_x','155_x','156_x','157_x','158_x','159_x','160_x','
161_x','162_x','163_x','164_x','165_x','166_x','167_x','168_x','169_x','170_x','171_x','172_x','17
3_x','174_x','175_x','176_x','177_x','178_x','179_x','180_x','181_x','182_x','183_x','184_x','185_
x','186_x','187_x','188_x','189_x','190_x','191_x','192_x','193_x','194_x','195_x','196_x','197_x'
,'198_x','199_x','200_x','201_x','202_x','203_x','204_x','205_x','206_x','207_x','208_x','209_x','
210_x','211_x','212_x','213_x','214_x','215_x','216_x','217_x','218_x','219_x','220_x','221_x','22
2_x','223_x','224_x','225_x','226_x','227_x','228_x','229_x','230_x','231_x','232_x','233_x','234_
x','235_x','236_x','237_x','238_x','239_x','240_x','241_x','242_x','243_x','244_x','245_x','246_x'
,'247_x','248_x','249_x','250_x','251_x','252_x','253_x','254_x','255_x','256_x','257_x','258_x','
259_x','260_x','261_x','262_x','263_x','264_x','265_x','266_x','267_x','268_x','269_x','270_x','27
1_x','272_x','273_x','274_x','275_x','276_x','277_x','278_x','279_x','280_x','281_x','282_x','283_
x','284_x','285_x','286_x','287_x','288_x','289_x','290_x','291_x','292_x','293_x','294_x','295_x'
,'296_x','297_x','298_x','299_x','300_x','301_x','302_x','303_x','304_x','305_x','306_x','307_x','
308_x','309_x','310_x','311_x','312_x','313_x','314_x','315_x','316_x','317_x','318_x','319_x','32
0_x','321_x','322_x','323_x','324_x','325_x','326_x','327_x','328_x','329_x','330_x','331_x','332_
x','333_x','334_x','335_x','336_x','337_x','338_x','339_x','340_x','341_x','342_x','343_x','344_x'
,'345_x','346_x','347_x','348_x','349_x','350_x','351_x','352_x','353_x','354_x','355_x','356_x','
357_x','358_x','359_x','360_x','361_x','362_x','363_x','364_x','365_x','366_x','367_x','368_x','36
9_x','370_x','371_x','372_x','373_x','374_x','375_x','376_x','377_x','378_x','379_x','380_x','381_
x','382_x','383_x','0_y','1_y','2_y','3_y','4_y','5_y','6_y','7_y','8_y','9_y','10_y','11_y','12_y'
,'13_y','14_y','15_y','16_y','17_y','18_y','19_y','20_y','21_y','22_y','23_y','24_y','25_y','26_y',
'27_y','28_y','29_y','30_y','31_y','32_y','33_y','34_y','35_y','36_y','37_y','38_y','39_y','40_y','
41_y','42_y','43_y','44_y','45_y','46_y','47_y','48_y','49_y','50_y','51_y','52_y','53_y','54_y','5
5_y','56_y','57_y','58_y','59_y','60_y','61_y','62_y','63_y','64_y','65_y','66_y','67_y','68_y','69
_y','70_y','71_y','72_y','73_y','74_y','75_y','76_y','77_y','78_y','79_y','80_y','81_y','82_y','83_
y','84_y','85_y','86_y','87_y','88_y','89_y','90_y','91_y','92_y','93_y','94_y','95_y','96_y','97_y
','98_y','99_y','100_y','101_y','102_y','103_y','104_y','105_y','106_y','107_y','108_y','109_y','11
0_y','111_y','112_y','113_y','114_y','115_y','116_y','117_y','118_y','119_y','120_y','121_y','122_
y','123_y','124_y','125_y','126_y','127_y','128_y','129_y','130_y','131_y','132_y','133_y','134_y'
,'135_y','136_y','137_y','138_y','139_y','140_y','141_y','142_y','143_y','144_y','145_y','146_y','
147_y','148_y','149_y','150_y','151_y','152_y','153_y','154_y','155_y','156_y','157_y','158_y','15
9_y','160_y','161_y','162_y','163_y','164_y','165_y','166_y','167_y','168_y','169_y','170_y','171_
y','172_y','173_y','174_y','175_y','176_y','177_y','178_y','179_y','180_y','181_y','182_y','183_y'
,'184_y','185_y','186_y','187_y','188_y','189_y','190_y','191_y','192_y','193_y','194_y','195_y','
196_y','197_y','198_y','199_y','200_y','201_y','202_y','203_y','204_y','205_y','206_y','207_y','20
8_y','209_y','210_y','211_y','212_y','213_y','214_y','215_y','216_y','217_y','218_y','219_y','220_
y','221_y','222_y','223_y','224_y','225_y','226_y','227_y','228_y','229_y','230_y','231_y','232_y'
,'233_y','234_y','235_y','236_y','237_y','238_y','239_y','240_y','241_y','242_y','243_y','244_y','
245_y','246_y','247_y','248_y','249_y','250_y','251_y','252_y','253_y','254_y','255_y','256_y','25
7_y','258_y','259_y','260_y','261_y','262_y','263_y','264_y','265_y','266_y','267_y','268_y','269_
y','270_y','271_y','272_y','273_y','274_y','275_y','276_y','277_y','278_y','279_y','280_y','281_y'
,'282_y','283_y','284_y','285_y','286_y','287_y','288_y','289_y','290_y','291_y','292_y','293_y','
294_y','295_y','296_y','297_y','298_y','299_y','300_y','301_y','302_y','303_y','304_y','305_y','30
6_y','307_y','308_y','309_y','310_y','311_y','312_y','313_y','314_y','315_y','316_y','317_y','318_
y','319_y','320_y','321_y','322_y','323_y','324_y','325_y','326_y','327_y','328_y','329_y','330_y'
,'331_y','332_y','333_y','334_y','335_y','336_y','337_y','338_y','339_y','340_y','341_y','342_y','
343_y','344_y','345_y','346_y','347_y','348_y','349_y','350_y','351_y','352_y','353_y','354_y','35
5_y','356_y','357_y','358_y','359_y','360_y','361_y','362_y','363_y','364_y','365_y','366_y','367_
y','368_y','369_y','370_y','371_y','372_y','373_y','374_y','375_y','376_y','377_y','378_y','379_y'
,'380_y','381_y','382_y','383_y'], chunksize=chunksize, iterator=True, encoding='utf-8'):
        df.index += index_start
        j += 1
        print('{} rows'.format(j*chunksize))
        df.tosql('test_data', disk_engine, if_exists='append')
        index_start = df.index[-1]+1
```

In [0]:

```
#creating a connection
def create_connection(db):
    conn = sqlite3.connect(db)
    return conn

def check_table_exists(conn):
    cursr = conn.cursor()
    str = 'SELECT name FROM sqlite_master WHERE type="table"'
    table_names = cursr.execute(str)
    tables = table_names.fetchall()
    print(tables)
```

In [0]:

```
#read the train.db
read_train_db = 'train.db'
conn_r = create_connection(read_train_db)
check_table_exists(conn_r)
conn_r.close()

#read the val.db
read_val_db = 'val.db'
conn_r = create_connection(read_val_db)
check_table_exists(conn_r)
conn_r.close()

#read the test.db
read_test_db = 'test.db'
conn_r = create_connection(read_test_db)
check_table_exists(conn_r)
conn_r.close()
```

In [0]:

```
#sampling only 700000 in train and 300000 in val as we already split it
def create_df(db, number):
    if os.path.isfile(db):
        conn_r = create_connection(db)

        if conn_r is not None:
            data = pd.read_sql_query('SELECT * FROM train_data LIMIT {}'.format(number), conn_r)
            conn_r.commit()
            conn_r.close()
```

In [0]:

```
#trainin_df
final_df_train = create_df(read_train_db, 700001)
final_df_val = create_df(read_val_db, 300001)
final_df_test = create_df(read_test_db, 50001)
```

In [0]:

```
final_df_train.head()
```

In [0]:

```
# remove the first row
data.drop(data.index[0], inplace=True)
y_true = data['is_duplicate']
data.drop(['Unnamed: 0', 'id','index','is_duplicate'], axis=1, inplace=True)
```

In [0]:

```
final_df_val.head()
```

In [0]:

```
# remove the first row
data.drop(data.index[0], inplace=True)
y_true = data['is_duplicate']
data.drop(['Unnamed: 0', 'id','index','is_duplicate'], axis=1, inplace=True)
```

In [0]:

```
final_df_test.head()
```

In [0]:

```
# remove the first row
data.drop(data.index[0], inplace=True)
y_true = data['is_duplicate']
data.drop(['Unnamed: 0', 'id','index','is_duplicate'], axis=1, inplace=True)
```

8.8 Converting strings to Numerics

In [0]:

```
# after we read from sql table each entry was read it as a string
# we convert all the features into numaric before we apply any model
def strings_to_numeric(df):
    cols = list(df.columns)
    for i in cols:
        df[i] = data[i].apply(pd.to_numeric)
        print(i)
```

In [0]:

```
final_train_df = strings_to_numeric(final_train_df)
final_var_df = strings_to_numeric(final_val_df)
final_test_df = strings_to_numeric(final_test_df)
```

10. Modelling

10.1 Creating confusion matrix

In [60]:

```
# 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 predicted 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 two
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 two
```

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

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

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

    plt.show()
```

10.2 Building a Random model

In [61]:

```
y_train = result_train['is_duplicate']
y_val = result_val['is_duplicate']
y_test = result_test['is_duplicate']
```

In [62]:

```
X_train = result_train.drop(labels='is_duplicate', axis=1, )
X_val = result_val.drop(labels='is_duplicate', axis=1)
X_test = result_test.drop(labels='is_duplicate', axis=1)
```

In [63]:

```
print(X_train.shape)
print(X_val.shape)
print(X_test.shape)
```

```
(198102, 219)
(121287, 219)
(84901, 219)
```

In [64]:

```
X_train.head()
```

Out[64]:

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	...	86_y	87
0	209577	0.999967	0.599988	0.999986	0.777769	0.999990	0.624996	1.0	1.0	6.0	...	0.000075	0.0012
1	17392	0.999967	0.999967	0.499975	0.333322	0.799984	0.666656	1.0	0.0	1.0	...	0.000448	0.0006
2	14251	0.666644	0.499988	0.999967	0.999967	0.833319	0.714276	0.0	1.0	1.0	...	0.000174	0.0005

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	...	86_y	87
3	265830	0.272725	0.249998	0.249997	0.199998	0.249999	0.208332	0.0	0.0	4.0	...	0.000124	0.0015
4	123216	0.999967	0.999967	0.799984	0.799984	0.874989	0.874989	1.0	1.0	0.0	...	0.000776	0.0012

5 rows × 219 columns

Note:

- We are going to consider only 70k points for training and 30k points for validation bcoz of lack of computational power

In [65]:

```
X_train = X_train.iloc[0:70000,:]
y_train = y_train[0:70000]

X_val = X_val.iloc[0:30000,:]
y_val = y_val[0:30000]
```

In [66]:

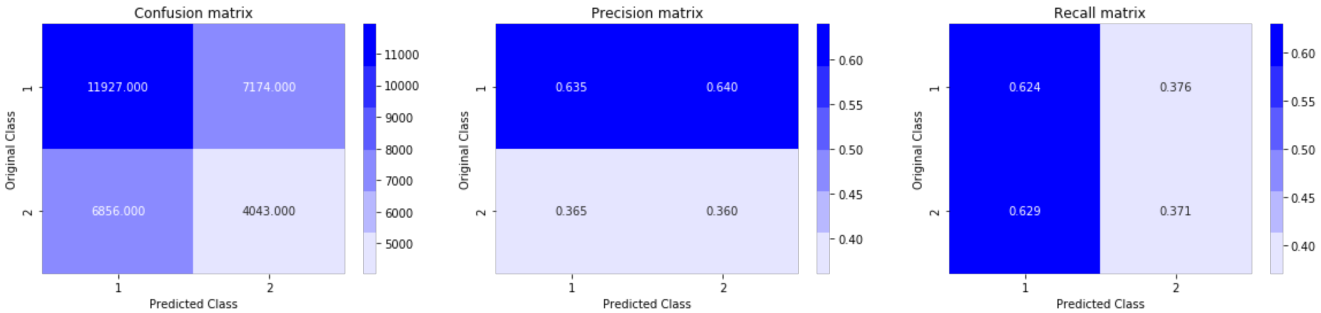
```
print(X_train.shape)
print(y_train.shape)
```

```
(70000, 219)
(70000,)
```

In [67]:

```
dummy_clf = DummyClassifier(strategy='stratified')
dummy_clf.fit(X_train, y_train)
y_pred = dummy_clf.predict(X_val)

print('Log loss for the random dummy model', log_loss(y_val, y_pred))
plot_confusion_matrix(y_val, y_pred)
```

```
Log loss for the random dummy model 16.152825637752038
```



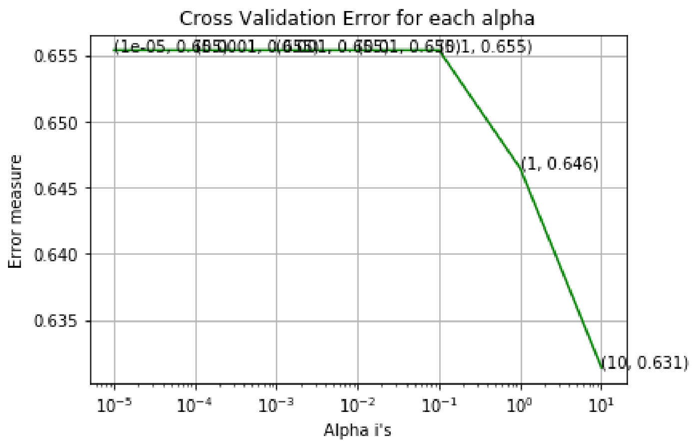
10.3 Logistic Regression

In [69]:

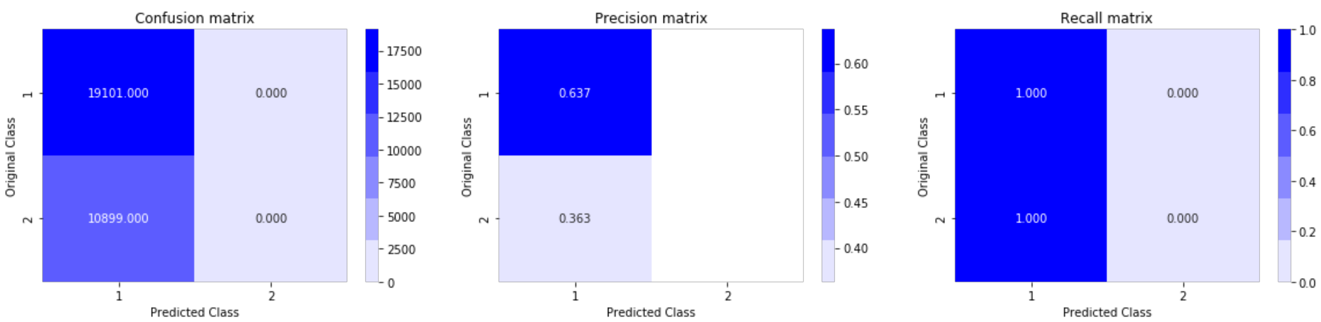
```
alpha = [10 ** x for x in range(-5, 2)] # hyperparam for SGD classifier.

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

```python
fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in 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.xscale('log')
plt.show()


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

predict_y = sig_clf.predict_proba(X_train)
print('For values of best 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(X_val)
print('For values of best alpha = ', best_alpha, "The test log loss is:",log_loss(y_val, 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_val, predicted_y)
```

```
For values of alpha =  1e-05 The log loss is: 0.6554000609637015
For values of alpha =  0.0001 The log loss is: 0.6554000609637015
For values of alpha =  0.001 The log loss is: 0.6554000609637015
For values of alpha =  0.01 The log loss is: 0.6554000609637015
For values of alpha =  0.1 The log loss is: 0.6554000609637015
For values of alpha =  1 The log loss is: 0.6464775961647082
For values of alpha =  10 The log loss is: 0.6314334520562241
```




```
For values of best alpha =  10 The train log loss is: 0.6354490856754549
For values of best alpha =  10 The test log loss is: 0.6314334520562241
Total number of data points : 30000
```



10.4 XGBOOST

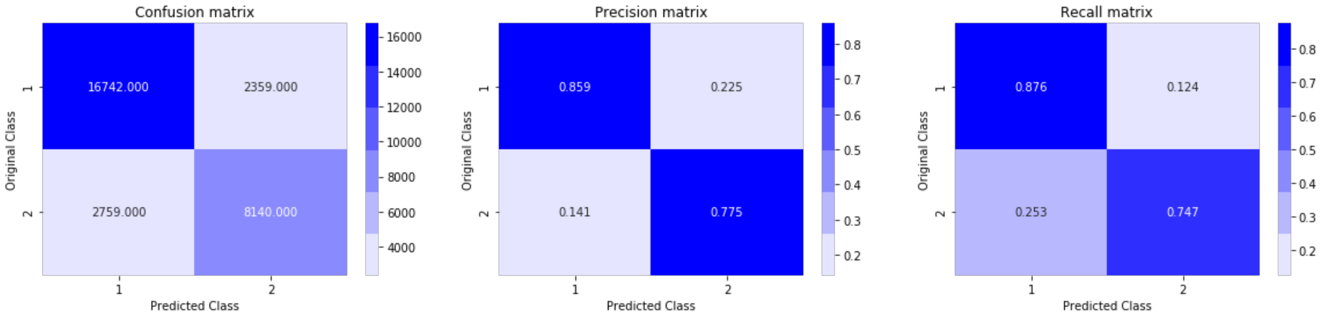
In [70]:

```
from xgboost import XGBClassifier
xgb_clf = XGBClassifier()
xgb_clf.fit(X_train,y_train)

y_pred = xgb_clf.predict(X_val)
print('Log loss:', log_loss(y_val, y_pred, labels=xgb_clf.classes_, eps=1e-15))
```

```
Log loss: 5.892378127983023
```

In [71]:

```
plot_confusion_matrix(y_val, y_pred)
```



12. TASK -2 :

- Hyperparameter tuning of XGBOOST - Since it is computationally expensive i take only this three hyperparameters. https://blog.cambridgespark.com/hyperparameter-tuning-in-xgboost-4ff9100a3b2f

In [72]:

```
from sklearn.model_selection import RandomizedSearchCV
```

In [73]:

```
XGB_clf = XGBClassifier()
params = {
          'learning_rate' : [0.01, 0.05, 0.1, 0.2],
          'n_estimators' : [100, 300, 500, 1000, 2000],
          'max_depth' : [3, 5, 10],
          'subsample' : [0.1, 0.3, 0.5, 1]
        }

random_search = RandomizedSearchCV(estimator=xgb_clf, param_distributions=params,
scoring='neg_log_loss', cv=2, return_train_score=True, n_jobs=-1 )
```

In [74]:

```
X_train.shape
```

Out[74]:

```
(70000, 219)
```

In [75]:

```
random_search = random_search.fit(X_train, y_train)
```

In [76]:

```
random_search.best_params_
```

Out[76]:

```
{'subsample': 1, 'n_estimators': 500, 'max_depth': 5, 'learning_rate': 0.05}
```

In [77]:

```
random_search.best_params_['n_estimators']
```

Out[77]:

```
500
```

Summary:

In [78]:

```
from prettytable import PrettyTable

x = PrettyTable()
x.field_names = ['Model', 'Best learning rate', 'Best n_estimators', 'Best max_depth', 'Best subsam
ple']
x.add_row(['XGBoost', random_search.best_params_['learning_rate'], random_search.best_params_['n_e
stimators'], random_search.best_params_['max_depth'], random_search.best_params_['subsample']])
print(x)
```

```
+---------+--------------------+-------------------+----------------+----------------+
|  Model  | Best learning rate | Best n_estimators | Best max_depth | Best subsample |
+---------+--------------------+-------------------+----------------+----------------+
| XGBoost |        0.05        |        500        |       5        |       1        |
+---------+--------------------+-------------------+----------------+----------------+
```

11. TASK -1

- Applying tfidf instead of tfidfw2v
- df2_train_q1 - tfidf for q1
- df2_train_q2 - tfidf for q2
- df2 ==> df_fe_without_preprocessing
- df3 ==>nlp_preprocessed

11.1 SPlittingt the dataset

In [ ]:

```
df_train, df_val, y_train, y_val = train_test_split(df, df.iloc[:, -1:], test_size = 0.3, random_st
ate=0 , stratify = df.iloc[:,-1:])
df_train, df_test, y_train, y_test = train_test_split(df_train, y_train, test_size= 0.3, random_sta
te=0, stratify = y_train)
```

11.2 Get the training questions

In [0]:

```
train_questions = df_train['question1'] + df_train['question2']
train_questions.head()
```

Out[0]:

```
0    what is the step by step guide to invest in sh...
1    what is the story of kohinoor  koh i noor  dia...
2    how can i increase the speed of my internet co...
3    why am i mentally very lonely  how can i solve...
4    which one dissolve in water quikly sugar  salt...
dtype: object
```

11.3 TFIDF

In [84]:

```
vec = TfidfVectorizer(min_df=25)
vec.fit_transform(train_questions.values)
```

Out[84]:

```
<198102x7316 sparse matrix of type '<class 'numpy.float64'>'
 with 2863942 stored elements in Compressed Sparse Row format>
```

In [85]:

```
pd.DataFrame.sparse.from_spmatrix(vec.transform(df_train['question1'].values), index = df_train.ind
ex)
```

Out[85]:

	0	1	2	3	4	5	6	7	8	9	...	7306	7307	7308	7309	7310	7311	7312	7313	7314	7315
209577	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17392	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14251	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
265830	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
123216	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
181830	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
183325	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
346248	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
342627	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21773	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

198102 rows × 7316 columns

In [86]:

```
df2_train_q1 = pd.DataFrame.sparse.from_spmatrix(vec.transform(df_train['question1'].values), index
= df_train.index)
df2_train_q2 = pd.DataFrame.sparse.from_spmatrix(vec.transform(df_train['question2'].values), index
= df_train.index)
```

In [87]:

```
df2_train_q1['id'] = df_train['id']
df2_train_q2['id'] = df_train['id']
df2_train_q1.head()
```

Out[87]:

	0	1	2	3	4	5	6	7	8	9	...	7307	7308	7309	7310	7311	7312	7313	7314	7315	id
209577	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	209577
17392	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17392
14251	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14251
265830	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	265830
123216	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	123216

5 rows × 7317 columns

In [88]:

```
df2_val_q1 = pd.DataFrame.sparse.from_spmatrix(vec.transform(df_val['question1'].values), index=df_
val.index)
df2_val_q2 = pd.DataFrame.sparse.from_spmatrix(vec.transform(df_val['question2'].values), index=df_
val.index)
```

In [89]:

```
df2_val_q1['id'] = df_val['id']
df2_val_q2['id'] = df_val['id']
df2_val_q2.head()
```

Out[89]:

	0	1	2	3	4	5	6	7	8	9	...	7307	7308	7309	7310	7311	7312	7313	7314	7315	id
40373	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	40373
218089	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	218089
184729	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	184729
218907	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	218907
224215	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	224215

5 rows × 7317 columns

In [90]:

```
df2_test_q1 = pd.DataFrame.sparse.from_spmatrix(vec.transform(df_test['question1'].values), index=d
f_test.index)
df2_test_q2 = pd.DataFrame.sparse.from_spmatrix(vec.transform(df_test['question2'].values), index=d
f_test.index)
```

In [91]:

```
df2_test_q1['id'] = df_test['id']
df2_test_q2['id'] = df_test['id']
df2_test_q2.head()
```

Out[91]:

	0	1	2	3	4	5	6	7	8	9	...	7307	7308	7309	7310	7311	7312	7313	7314	7315	id
372980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	372980
14252	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14252
102303	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102303
274316	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	274316
370597	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	370597

5 rows × 7317 columns

11.4 Importing other dataframes

11.4.1 Importing df_fe_without_preprocessing

In [92]:

```
# 1. importing the df_fe_without_preprocessing
df2 = pd.read_csv('df_fe_without_preprocessing_train.csv', encoding='latin-1')
df2.head()
```

Out[92]:

id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common
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	66	57	14	12	10.0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	4	1	51	88	8	13	4.0
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0	1	1	73	59	14	10	4.0
3	3	7	8	Why am I mentally very lonely? How can I solve...	Find the remainder when [math]23^{24}[/math] i...	0	1	1	50	65	11	9	0.0
4	4	9	10	Which one dissolve in water quikly sugar, salt...	Which fish would survive in salt water?	0	3	1	76	39	13	7	2.0

In [93]:

```
df2.drop(labels=['qid1', 'qid2', 'question1', 'question2'], axis=1, inplace=True)
df2.head()
```

Out[93]:

	id	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	word_share	freq_q1+q2
0	0	0	1	1	66	57	14	12	10.0	23.0	0.434783	2
1	1	0	4	1	51	88	8	13	4.0	20.0	0.200000	5
2	2	0	1	1	73	59	14	10	4.0	24.0	0.166667	2
3	3	0	1	1	50	65	11	9	0.0	19.0	0.000000	2
4	4	0	3	1	76	39	13	7	2.0	20.0	0.100000	4

In [94]:

```
#Splitting it
df2_train, df2_val, y_train, y_val = train_test_split(df2, df.iloc[:, -1:], test_size=0.3, random_s
tate=0, stratify = df.iloc[:,-1:])
df2_train, df2_test, y_train, y_test = train_test_split(df2_train, y_train, test_size=0.3, random_s
tate=0, stratify = y_train)
```

In [95]:

```
print(df2_train.shape)
print(df2_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(198102, 13)
(84901, 13)
(198102, 1)
(84901, 1)
```

In [96]:

```
df2_train.head()
```

Out[96]:

	id	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_Common	word_Total	word_share	fi
209577	209577	0	4	2	75	46	16	10	8.0	24.0	0.333333	
17392	17392	1	1	1	29	33	5	6	4.0	11.0	0.363636	
14251	14251	0	1	1	58	38	7	6	5.0	13.0	0.384615	
265830	265830	0	1	5	124	136	20	24	5.0	42.0	0.119048	
123216	123216	1	1	1	51	51	8	8	7.0	16.0	0.437500	

11.4.2 NLP_features

In [97]:

```
# 2. importing nlp_features
df3 = pd.read_csv('nlp_features_train.csv', encoding='latin-1')
df3.head()
```

Out[97]:

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	...	ctc_max	last_word_eq	first_word_
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	0.999980	0.833319	0.999983	0.999983	...	0.785709	0.0	
1	1	3	4	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0	0.799984	0.399996	0.749981	0.599988	...	0.466664	0.0	
2	2	5	6	how can i increase the speed of my internet co...	how can internet speed be increased by hacking...	0	0.399992	0.333328	0.399992	0.249997	...	0.285712	0.0	
3	3	7	8	why am i mentally very lonely how can i solve...	find the remainder when math 23 24 math i...	0	0.000000	0.000000	0.000000	0.000000	...	0.000000	0.0	
4	4	9	10	which one dissolve in water quikly sugar salt...	which fish would survive in salt water	0	0.399992	0.199998	0.999950	0.666644	...	0.307690	0.0	

5 rows × 21 columns

In [98]:

```
df3.drop(labels=['qid1', 'qid2', 'question1', 'question2', 'is_duplicate'], axis=1, inplace=True)
df3.head()
```

Out[98]:

	id	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_rati
0	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	0.0	1.0	2.0	13.0	10
1	1	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	0.0	1.0	5.0	12.5	8
2	2	0.399992	0.333328	0.399992	0.249997	0.399996	0.285712	0.0	1.0	4.0	12.0	6
3	3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0	0.0	2.0	12.0	3
4	4	0.399992	0.199998	0.999950	0.666644	0.571420	0.307690	0.0	1.0	6.0	10.0	6

In [99]:

```
#Splitting it
df3_train, df3_val, y_train, y_val = train_test_split(df3, df.iloc[:, -1:], test_size=0.3, random_s
tate=0, stratify=df.iloc[:, -1:])
df3_train, df3_test, y_train, y_test = train_test_split(df3_train, y_train, test_size=0.3, random_s
tate=0, stratify=y_train)
```

In [100]:

```
print(df3_train.shape)
print(df3_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(198102, 16)
(84901, 16)
(198102, 1)
(84901, 1)
```

In [101]:

```
df3_train.head()
```

Out[101]:

	id	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len	tok
209577	209577	0.999967	0.599988	0.999986	0.777769	0.999990	0.624996	1.0	1.0	6.0	13.0	
17392	17392	0.999967	0.999967	0.499975	0.333322	0.799984	0.666656	1.0	0.0	1.0	5.5	
14251	14251	0.666644	0.499988	0.999967	0.999967	0.833319	0.714276	0.0	1.0	1.0	6.5	
265830	265830	0.272725	0.249998	0.249997	0.199998	0.249999	0.208332	0.0	0.0	4.0	22.0	
123216	123216	0.999967	0.999967	0.799984	0.799984	0.874989	0.874989	1.0	1.0	0.0	8.0	

In [102]:

```
print(df2_train_q1.shape)
print(df2_train_q2.shape)
print(df2_train.shape)
print(df3_train.shape)
print('='*50)
print(df2_val_q1.shape)
print(df2_val_q2.shape)
print(df2_val.shape)
print(df3_val.shape)
```

```
(198102, 7317)
(198102, 7317)
(198102, 13)
(198102, 16)
==================================================
(121287, 7317)
(121287, 7317)
(121287, 13)
(121287, 16)
```

In [103]:

```
#merging all by id
df3_train = df3_train.merge(df2_train, on='id', how='left')
df3_train = df3_train.merge(df2_train_q1, on='id', how='left')
assign_train = df3_train.merge(df2_train_q2, on='id', how='left')

df3_val = df3_val.merge(df2_val, on='id', how='left')
df3_val = df3_val.merge(df2_val_q1, on='id', how='left')
assign_val = df3_val.merge(df2_val_q2, on='id', how='left')
```

```
df3_test = df3_test.merge(df2_test, on='id', how='left')
df3_test = df3_test.merge(df2_test_q1, on='id', how='left')
assign_test = df3_test.merge(df2_test_q2, on='id', how='left')
```

In [104]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/assign_train', 'wb') as f:
    pickle.dump(assign_train, f)
```

In [105]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/assign_val', 'wb') as f:
    pickle.dump(assign_val, f)
```

In [106]:

```
import pickle
with open('/home/ubuntu/Quora/*Assign 22 -Quora/assign_test', 'wb') as f:
    pickle.dump(assign_test, f)
```

In [107]:

```
X_train = assign_train.iloc[0:70000,:]
X_val = assign_val.iloc[0:30000,:]
```

In [108]:

```
y_train = y_train[0:70000]
y_val = y_val[0:30000]
```

In [109]:

```
print(X_train.shape)
print(y_train.shape)
print(X_val.shape)
print(y_val.shape)
print()
```

```
(70000, 14660)
(70000, 1)
(30000, 14660)
(30000, 1)
```

11.5 Modelling - Logistgic Regression

In [80]:

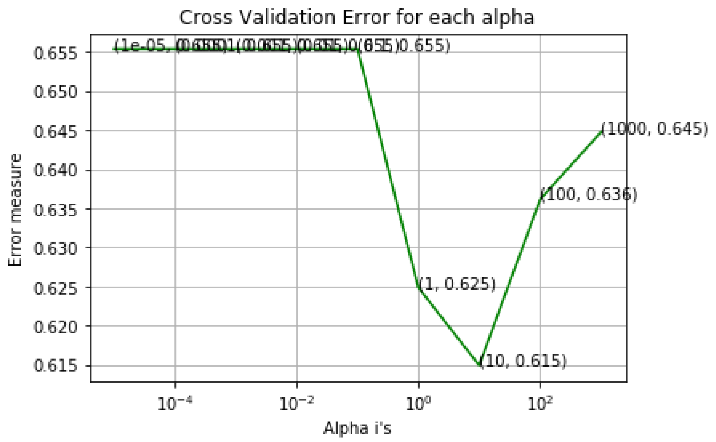
```
alpha = [10 ** i for i in range(-5, 4)]

log_error_array=[]
for i in alpha:
    clf = SGDClassifier(alpha=i, penalty='l2', loss='log', random_state=0)
    clf.fit(X_train, y_train)
    sig_clf = CalibratedClassifierCV(clf, method="sigmoid")
    sig_clf.fit(X_train, y_train)
    predict_y = sig_clf.predict_proba(X_val)
    log_error_array.append(log_loss(y_val, predict_y, labels=clf.classes_, eps=1e-15))
    print('For values of alpha = ', i, "The log loss is:",log_loss(y_val, predict_y, labels=clf.cla
sses_, eps=1e-15))
```

```
For values of alpha =  1e-05 The log loss is: 0.6554000609637015
For values of alpha =  0.0001 The log loss is: 0.6554000609637015
For values of alpha =  0.001 The log loss is: 0.6554000609637015
For values of alpha =  0.01 The log loss is: 0.6554000609637015
```

```
For values of alpha =  0.1 The log loss is: 0.6554000609637015
For values of alpha =  1 The log loss is: 0.6248822103768743
For values of alpha =  10 The log loss is: 0.6149182450360078
For values of alpha =  100 The log loss is: 0.6361725621636402
For values of alpha =  1000 The log loss is: 0.6447644179190515
```

In [81]:

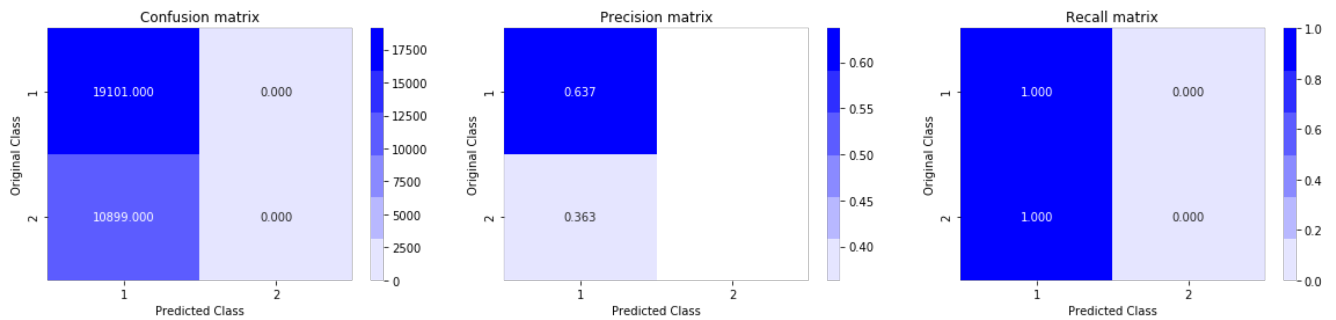
```
fig, ax = plt.subplots()
ax.plot(alpha, log_error_array,c='g')
for i, txt in enumerate(np.round(log_error_array,3)):
    ax.annotate((alpha[i],np.round(txt,3)), (alpha[i],log_error_array[i]))
plt.grid()
plt.title("Cross Validation Error for each alpha")
plt.xlabel("Alpha i's")
plt.ylabel("Error measure")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



In [82]:

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

predict_y = sig_clf.predict_proba(X_train)
print('For values of best 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(X_val)
print('For values of best alpha = ', best_alpha, "The test log loss is:",log_loss(y_val, 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_val, predicted_y)
```

```
For values of best alpha =  10 The train log loss is: 0.6354490856754549
For values of best alpha =  10 The test log loss is: 0.6314334520562241
Total number of data points : 30000
```



Summary

In [83]:

```
from prettytable import PrettyTable
x = PrettyTable()
x.field_names = ['Model', 'vectorizer','Best Alpha', 'Best Log loss']
x.add_row(['Logistic Regression', 'tfidf', best_alpha, 0.63078])
print(x)
```

```
+---------------------+------------+------------+---------------+
|        Model        | vectorizer | Best Alpha | Best Log loss |
+---------------------+------------+------------+---------------+
| Logistic Regression |   tfidf    |     10     |    0.63078    |
+---------------------+------------+------------+---------------+
```