Project --> Quora Questions Pair Similarity

importing libraries

import pandas as pd import numpy as np import matplotlib.pyplot as plt import seaborn as sns import warnings warnings.filterwarnings('ignore') import os import sys import datetime %matplotlib inline

from subprocess import check_output import gc import re import distance from nltk.corpus import stopwords from nltk.stem import PorterStemmer

plotly related libraries:

import plotly.offline as py py.init_notebook_mode(connected=True) import plotly.graph_objects as go import plotly.tools as tls

plt.yscale('log', nonposy='clip')

!pip install distance --upgrade

EDA

loading Train.csv file

In [2]:

```
df = pd.read_csv("train.csv")
df.head(3)
```

Out[2]:

	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

In [3]:

```
df.columns
```

Out[3]:

```
Index(['id', 'qid1', 'qid2', 'question1', 'question2', 'is_duplicate'], dtype='object')
```

In [4]:

```
len(df), df.isnull().sum(), df.is_duplicate.value_counts()
```

Out[4]:

```
(404290, id              0
 qid1            0
 qid2            0
 question1       1
 question2       2
 is_duplicate    0
 dtype: int64, 0    255027
 1    149263
 Name: is_duplicate, dtype: int64)
```

In [5]:

```
df.info()
```

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

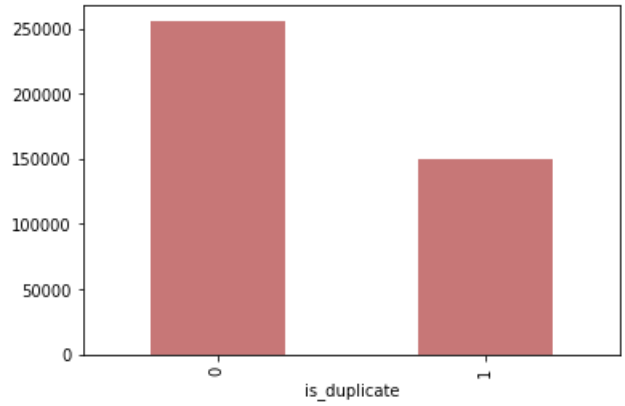
Disribution of data

In [6]:

```
df.groupby('is_duplicate')['id'].count().plot.bar(color="#C77777")
```

Out[6]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f83a68a4390>
```



In [7]:

```
##percent if son similar questions in dataset.
print(np.round(df['is_duplicate'].value_counts()[0] / len(df), 2))
```

```
0.63
```

No of Unique Questions

In [8]:

```
ques_uniq = pd.concat([df.qid1, df.qid2], axis=0).nunique()
ques_repeat = sum(pd.concat([df.qid1, df.qid2], axis=0).value_counts() > 1)
ques_max = sum(pd.concat([df.qid1, df.qid2], axis=0).value_counts().head(1))

print('Unique question counts = {}\nRepeated Question counts = {}\nMaximum quesion asked count = {
}'.format(ques_uniq, ques_repeat,ques_max ))
```

```
Unique question counts = 537933
Repeated Question counts = 111780
Maximum quesion asked count = 157
```

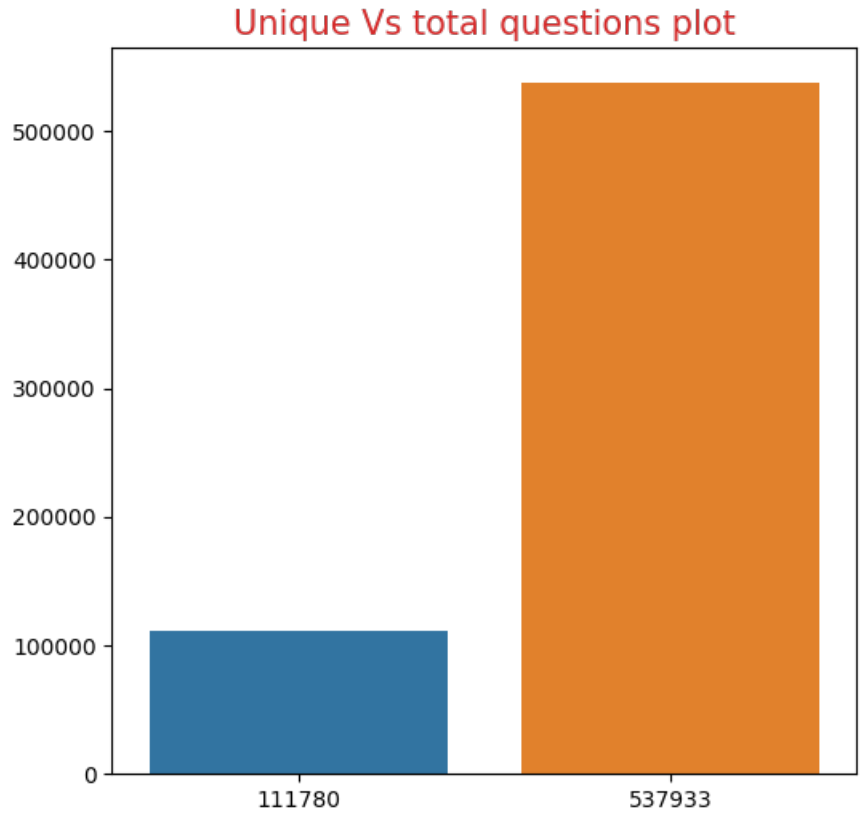
plotting unique questions vs. repeated question

In [9]:

```
plt.figure(figsize=(6, 6), dpi=100)

sns.barplot([ques_uniq, ques_repeat], [ques_uniq, ques_repeat])
plt.title('Unique Vs total questions plot', color='#D42929', size=15)
```

Out[9]:

```
Text(0.5, 1.0, 'Unique Vs total questions plot')
```



finding duplicate rows

In [10]:

```
duplicate_rows_df = pd.concat([df.qid1, df.qid2], axis=1).duplicated(subset=['qid1', 'qid2'])
len(duplicate_rows_df)

#conclusion: there's no duplicate rows found since the length of the dataframe equals to the the l
ength of the original df.
```

Out[10]:

```
404290
```

Null values checks and replacement

In [11]:

```
#Checking whether there are any rows with null values
nan_rows = df[df.isnull().any(1)]
print (nan_rows)

#filling NA values
print('\n' * 2)
df = df.fillna('Filling Null Values')
nan_rows = df[df.isnull().any(1)]
print (nan_rows)
```

```
            id    qid1    qid2                          question1  \
105780  105780  174363  174364    How can I develop android app?
201841  201841  303951  174364  How can I create an Android app?
```

```
363362  363362  493340  493341                                    NaN

                                                 question2  is_duplicate
105780                                                 NaN             0
201841                                                 NaN             0
363362  My Chinese name is Haichao Yu. What English na...              0


Empty DataFrame
Columns: [id, qid1, qid2, question1, question2, is_duplicate]
Index: []
```

In [12]:

```
len(df)
```

Out[12]:

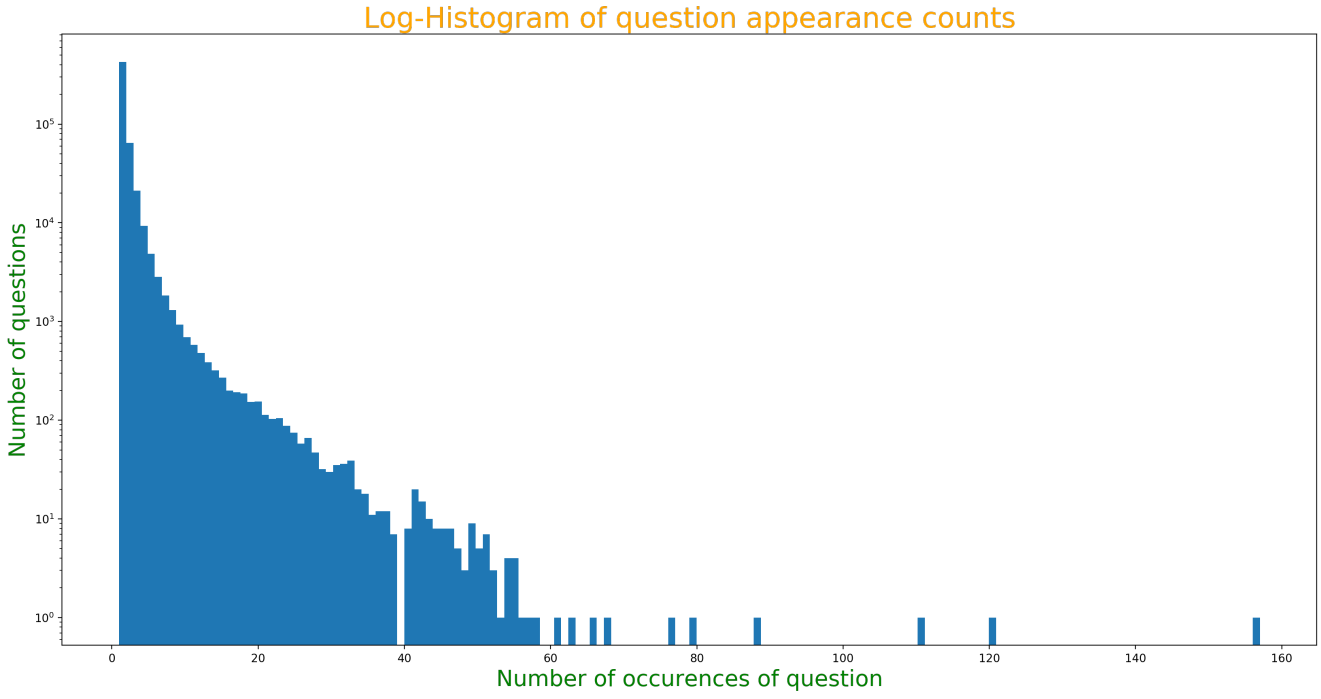
```
404290
```

Plotting

In [13]:

```
plt.figure(figsize=(20, 10), dpi=200)
plt.hist(pd.concat([df.qid1, df.qid2], axis=0).value_counts(), bins=160)
plt.yscale('log', nonposy='clip')
plt.title('Log-Histogram of question appearance counts', color='orange', size=25)
plt.xlabel('Number of occurences of question', size=20, color='green')
plt.ylabel('Number of questions', size=20, color='green')
print ('Maximum number of times a single question is repeated: {}\n'.format(max(pd.concat([df.qid1
, df.qid2], axis=0).value_counts())))
```

```
Maximum number of times a single question is repeated: 157
```



Functional Approach --Basic Feature Extraction (before cleaning)

Let us now construct a few features like:

- **freq_qid1** = Frequency of qid1's

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

In [14]:

```
def basic_feature_extraction(*args: 'variable number of arguments'):
    '''doing the basic feature extraction technique using column engineering and
       making into set of new columns
    '''
    global df

    #def common_word_count(w1, w2):
        #w1 = w1.strip('\n').split()
        #w2 = w2.strip('\n').split()
        #common_word = 0
        #tmp = w1 if len(w1) > len(w2) else w2
        #for words in tmp:
            #if (words in w1) & (words in w2):
                #common_word += 1
            #else:
                #continue
        #return common_word


    df['freq_qid1']       = df.groupby(args[0])[args[0]].transform('count')
    df['freq_qid2']       = df.groupby(args[1])[args[1]].transform('count')
    df['q1len']           = df[args[2]].apply(lambda x: len(x))
    df['q2len']           = df[args[3]].apply(lambda x: len(x))
    df['q1_n_words']      = df[args[2]].apply(lambda x: len(x.split()))
    df['q2_n_words']      = df[args[3]].apply(lambda x: len(x.split()))
    df['word_overlap']    = [set(x[3].strip('\n').lower().split()) & set(x[4].strip('\n').lower().sp
lit()) for x in df.values]
    df['word_common']     = df['word_overlap'].str.len()
    df['word_total']      = df[args[2]].apply(lambda x: len(x.strip('\n').split())) +
df[args[3]].apply(lambda x: len(x.strip('\n').split()))
    df['word_share']      = df['word_common'] / df['word_total']
    df['freq_q1+freq_q2'] = df['freq_qid1'] + df['freq_qid2']
    df['freq_q1-freq_q2'] = np.abs(df['freq_qid1'] - df['freq_qid2'])
    df.drop('word_overlap', axis=1, inplace=True)

    return df
```

In [15]:

```
%%time
df = basic_feature_extraction('qid1', 'qid2', 'question1', 'question2')
```

```
CPU times: user 6.4 s, sys: 392 ms, total: 6.8 s
Wall time: 6.79 s
```

In [16]:

```
df.columns
```

Out[16]:

```
Index(['id', 'qid1', 'qid2', 'question1', 'question2', 'is_duplicate',
       'freq_qid1', 'freq_qid2', 'q1len', 'q2len', 'q1_n_words', 'q2_n_words',
       'word_common', 'word_total', 'word_share', 'freq_q1+freq_q2',
       'freq_q1-freq_q2'],
      dtype='object')
```

In [16]:

```
df.head(3)
```

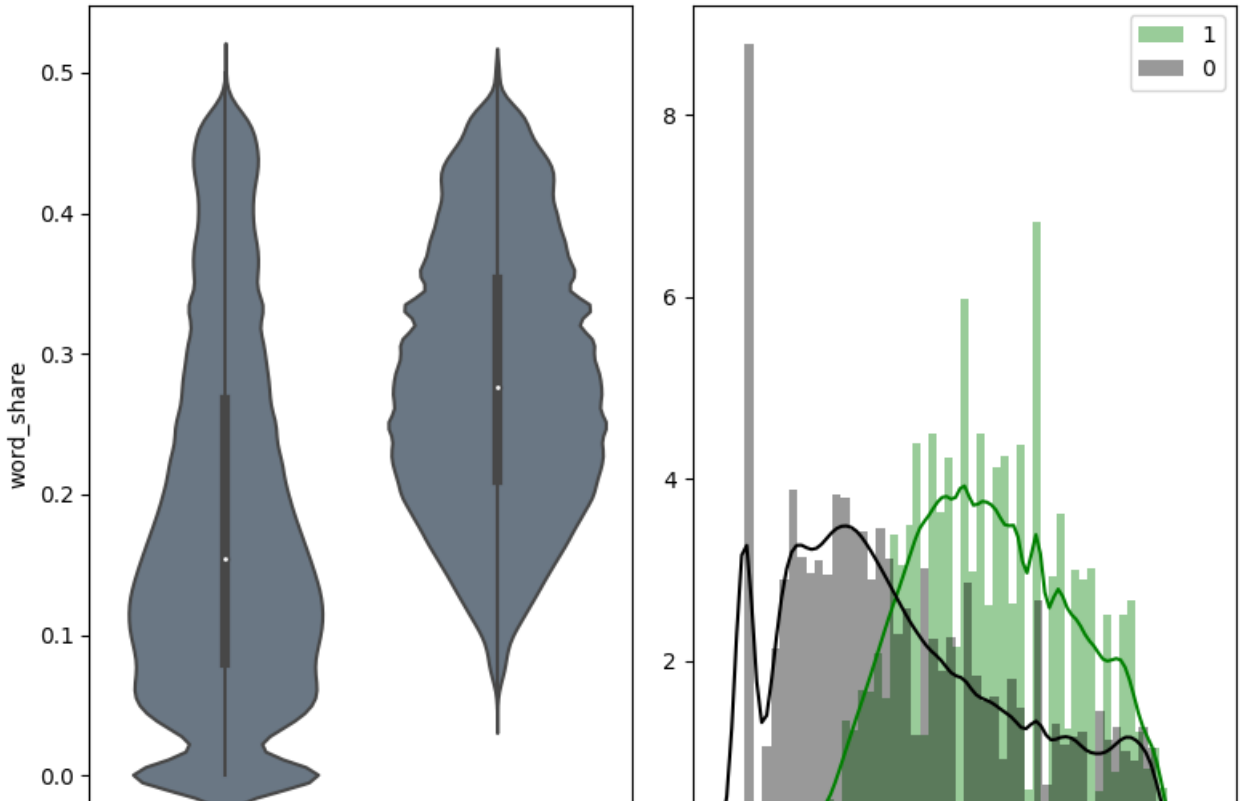
Out[16]:

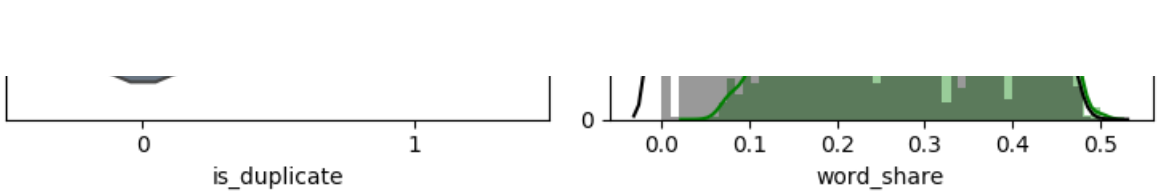
	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word_common	w
0	0	1	2	What is the step by step guide to invest in sh...	What is the step by step guide to invest in sh...	0	1	1	66	57	14	12	10	
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	4	1	51	88	8	13	4	
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	

Plotting - Distribution of word_share column

In [17]:

```
fig = plt.subplots(figsize=(8,6), dpi=100)
plt.subplot(121)
sns.violinplot(x='is_duplicate', y='word_share', data=df, color='#667788')

#plot2:
plt.subplot(122)
sns.distplot(df[df['is_duplicate'] == 1.0]['word_share'] , label = "1", color = 'green')
sns.distplot(df[df['is_duplicate'] == 0.0]['word_share'] , label = "0" , color = 'black')
plt.tight_layout()
plt.legend()
plt.show()
```



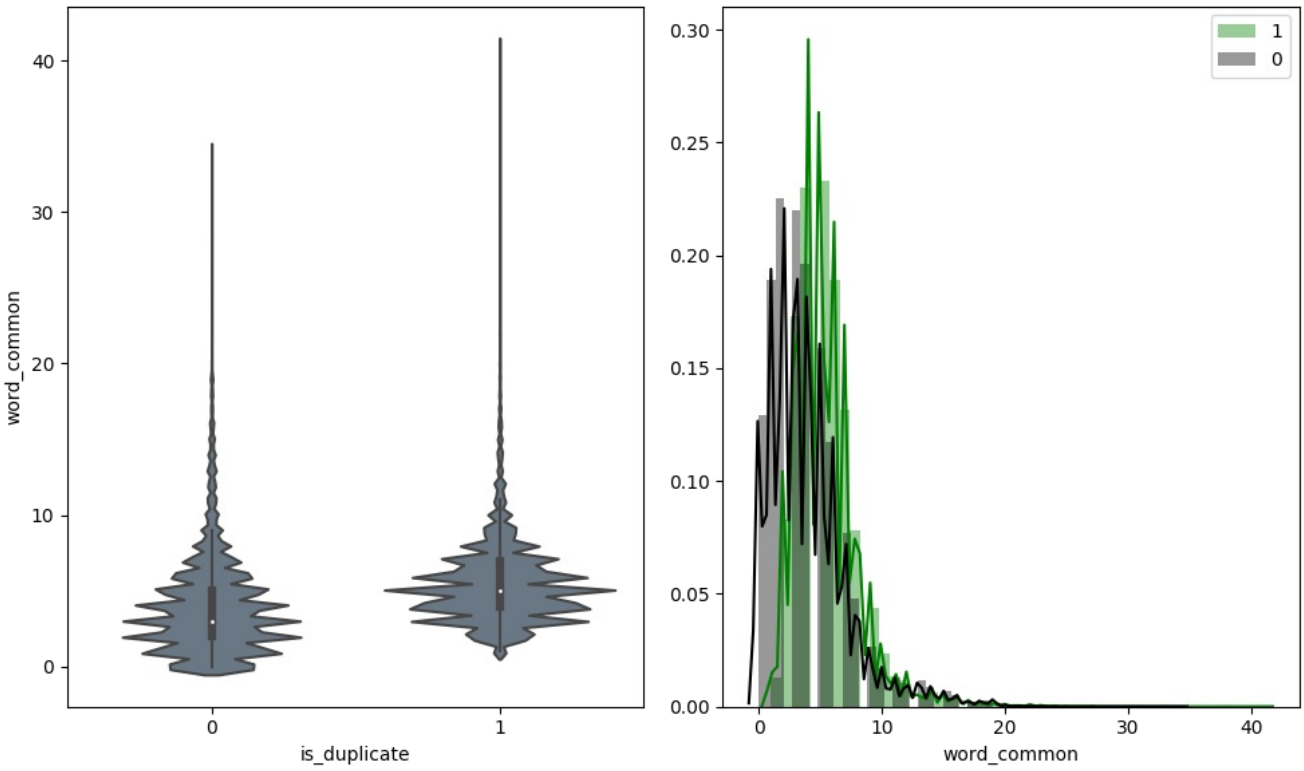


As we can see from above the column word_share has some importance as the labels are neither perfectly overlapping nor completely noon overlapping..we will see it later

Plotting - Distribution of word_common column

In [18]:

```
fig = plt.subplots(figsize=(10,6), dpi=100)
plt.subplot(121)
sns.violinplot(x='is_duplicate', y='word_common', data=df, color='#667788')

#plot2:
plt.subplot(122)
sns.distplot(df[df['is_duplicate'] == 1.0]['word_common'] , label = "1", color = 'green')
sns.distplot(df[df['is_duplicate'] == 0.0]['word_common'] , label = "0" , color = 'black')
plt.tight_layout()
plt.legend()
plt.show()
```

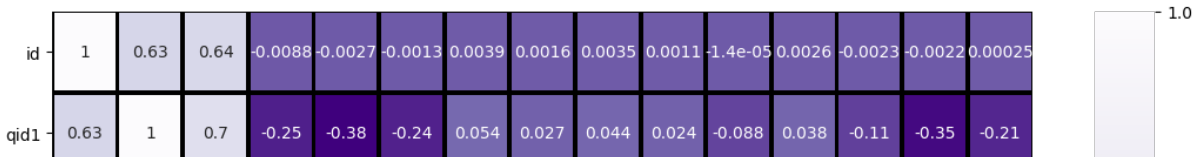


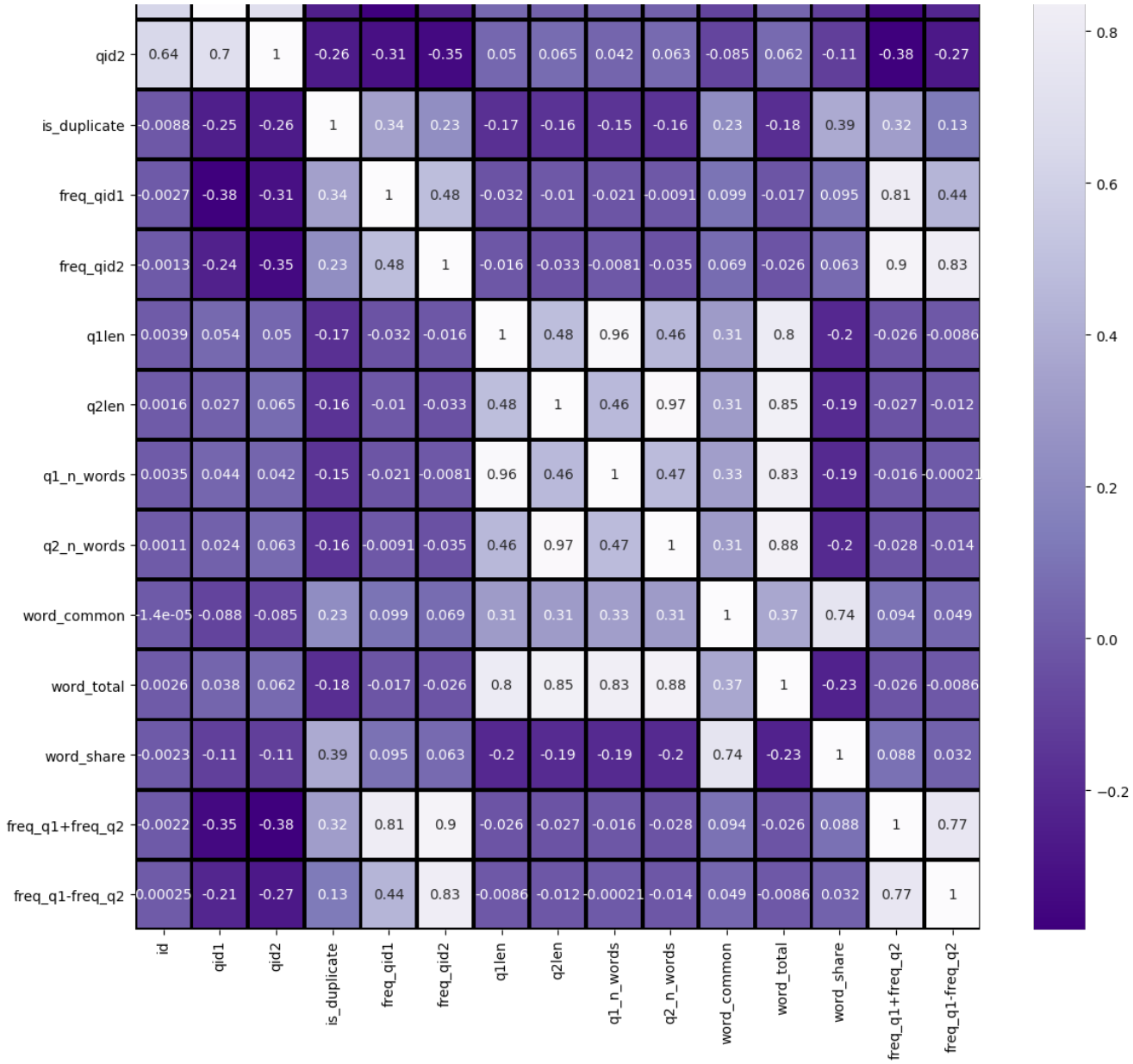
we could see that the word common feature is not as good as word_share feature as there are multiple overlaps seen in it

HEATMAP -To check collereation values

In [19]:

```
plt.figure(figsize=(12,12), dpi=100)
sns.heatmap(df.corr(), annot=True, linecolor='black', linewidth=2, cmap='Purples_r')
plt.tight_layout()
```





EDA- Advanced Feature extraction

Preliminary Preprocessing Text

1. Removal HTML tags through Beautiful soap

2. Lemmatization, removal of punctuation and removal of stopwords using SPACY

In [20]:

```
import spacy
from bs4 import BeautifulSoup
import string


nlp = spacy.load('en_core_web_sm')
stopwords = spacy.lang.en.stop_words.STOP_WORDS
print('spacy stop words lists are: {}'.format(len(stopwords)))



#defining function  using spacy
def preprocessing(x, stopwords=stopwords):

    #basic replacement and preprocessing:
```

```
    x = str(x).lower()
    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)

    #removing HTML, Punctuation( I am using string module) and LEMMATIZATION( using SPACY module)
    if type(x) == type(''):
        example1 = BeautifulSoup(x)
        x = example1.get_text()


    list_ = []

    for token in nlp(x):

        if token.lemma_ == '-PRON-':
            continue
        if token.is_punct:
            continue
        #if token.text in stopwords:
            #continue
        else:
            list_.append(token.lemma_)

    x = ' '.join(list_)

    return x
```

spacy stop words lists are: 326

In [21]:

```
df[df['question1'] == True]
df[df['question2'] == True]
df.reset_index(drop=True, inplace=True)
len(df)
```

Out[21]:

404290

Advanced Feature Extraction (NLP and Fuzzy Features)

In [22]:

```
%%time

SAFE_DIV = 0.0001
from fuzzywuzzy import fuzz

q1_tokens = df['question1'].apply(lambda x: preprocessing(x))
q2_tokens = df['question2'].apply(lambda x: preprocessing(x))

q1_tokens = q1_tokens.apply(lambda x: x.split())
q2_tokens = q2_tokens.apply(lambda x: x.split())

print(len(q1_tokens), len(q2_tokens))

q1_words = q1_tokens.apply(lambda x: set([arg for arg in x if arg not in stopwords]))
q2_words = q2_tokens.apply(lambda x: set([arg for arg in x if arg not in stopwords]))

print(len(q1_words), len(q2_words))
```

```
q1_stops = q1_tokens.apply(lambda x: set([arg for arg in x if arg in stopwords]))
q2_stops = q2_tokens.apply(lambda x: set([arg for arg in x if arg in stopwords]))

print(len(q1_stops), len(q2_stops))


common_word_count = [len(q1_words[i].intersection(q2_words[i])) for i in df.index]
print(len(common_word_count))

common_stop_count = [len(q1_stops[i].intersection(q2_stops[i])) for i in df.index]
print(len(common_stop_count))

common_token_count = [len(set(q1_tokens[i]).intersection(set(q2_tokens[i]))) for i in df.index]
print(len(common_token_count))


df['cwc_min']               = [common_word_count[i] / (min(len(list(q1_words[i])),
len(list(q2_words[i]))) + SAFE_DIV) for i in df.index]
df['cwc_max']               = [common_word_count[i] / (max(len(list(q1_words[i])),
len(list(q2_words[i]))) + SAFE_DIV) for i in df.index]
df['csc_min']               = [common_stop_count[i] / (min(len(list(q1_words[i])),
len(list(q2_words[i]))) + SAFE_DIV) for i in df.index]
df['csc_max']               = [common_stop_count[i] / (max(len(list(q1_words[i])),
len(list(q2_words[i]))) + SAFE_DIV) for i in df.index]
df['ctc_min']               = [common_token_count[i] / (min(len(q1_tokens[i]), len(q2_tokens[i])) +
SAFE_DIV) for i in df.index]
df['ctc_max']               = [common_token_count[i] / (max(len(q1_tokens[i]), len(q2_tokens[i])) +
SAFE_DIV) for i in df.index]

q1_tokens                   = q1_tokens.apply(lambda x: x + [' '])
q2_tokens                   = q2_tokens.apply(lambda x: x + [' '])

df['last_word_eq']          = [q1_tokens[i][-1] == q2_tokens[i][-1] for i in range(len(df))]
df['first_word_eq']         = [q1_tokens[i][0] == q2_tokens[i][0] for i in range(len(df))]
df['abs_len_diff']          = [abs(len(q1_tokens[i]) - len(q2_tokens[i])) for i in range(len(df))]
df['mean_len_diff']         = [(len(q1_tokens[i]) + len(q2_tokens[i])) / 2 for i in range(len(df))]
df["mean_len"]              = [(len(q1_tokens[i])+ len(q2_tokens[i]) + SAFE_DIV) for i in df.index]
df['longest_substr_ratio']  = [len(list(distance.lcsubstrings(df['question1'][i], df['question2'][i
]))) / min(len(df['question1'][i]), len(df['question2'][i]) + 1) for i in range(len(df))]
df["token_set_ratio"]       = df.apply(lambda x: fuzz.token_set_ratio(x["question1"], x["question2"
]), axis=1)
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"]), axis=
1)
df["fuzz_partial_ratio"]    = df.apply(lambda x: fuzz.partial_ratio(x["question1"], x["question2"])
, axis=1)

df['last_word_eq'] = df.last_word_eq.apply(lambda x : 1 if x == True else 0)
df['first_word_eq'] = df.first_word_eq.apply(lambda x: 1 if x == True else 0)
```

```
404290 404290
404290 404290
404290 404290
404290
404290
404290
CPU times: user 2h 36min 26s, sys: 22 s, total: 2h 36min 48s
Wall time: 2h 36min 51s
```

In [23]:

```
df.columns
```

Out[23]:

```
Index(['id', 'qid1', 'qid2', 'question1', 'question2', 'is_duplicate',
       'freq_qid1', 'freq_qid2', 'q1len', 'q2len', 'q1_n_words', 'q2_n_words',
       'word_common', 'word_total', 'word_share', 'freq_q1+freq_q2',
       'freq_q1-freq_q2', 'cwc_min', 'cwc_max', 'csc_min', 'csc_max',
       'ctc_min', 'ctc_max', 'last_word_eq', 'first_word_eq', 'abs_len_diff',
       'mean_len_diff', 'longest_substr_ratio', 'token_set_ratio',
       'token_sort_ratio', 'fuzz_ratio', 'fuzz_partial_ratio'],
```

```
      dtype='object')
```

In [24]:

```
df.isnull().sum()
```

Out[24]:

```
id                      0
qid1                    0
qid2                    0
question1               0
question2               0
is_duplicate            0
freq_qid1               0
freq_qid2               0
q1len                   0
q2len                   0
q1_n_words              0
q2_n_words              0
word_common             0
word_total              0
word_share              0
freq_q1+freq_q2         0
freq_q1-freq_q2         0
cwc_min                 0
cwc_max                 0
csc_min                 0
csc_max                 0
ctc_min                 0
ctc_max                 0
last_word_eq            0
first_word_eq           0
abs_len_diff            0
mean_len_diff           0
longest_substr_ratio    0
token_set_ratio         0
token_sort_ratio        0
fuzz_ratio              0
fuzz_partial_ratio      0
dtype: int64
```

Saving dataframe with Advance Preprocessed features onto disc

In [35]:

```
df.to_csv('Jalesh_Preprocess.csv', index=False)
```

In [36]:

```
df.head(2)
```

Out[36]:

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	...	last_word_eq	first_word_eq	abs_len_dif
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	...	1	1	2
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	...	1	1	5

2 rows × 33 columns

Analysis of extracted features

In [37]:

```
from wordcloud import WordCloud
```

In [38]:

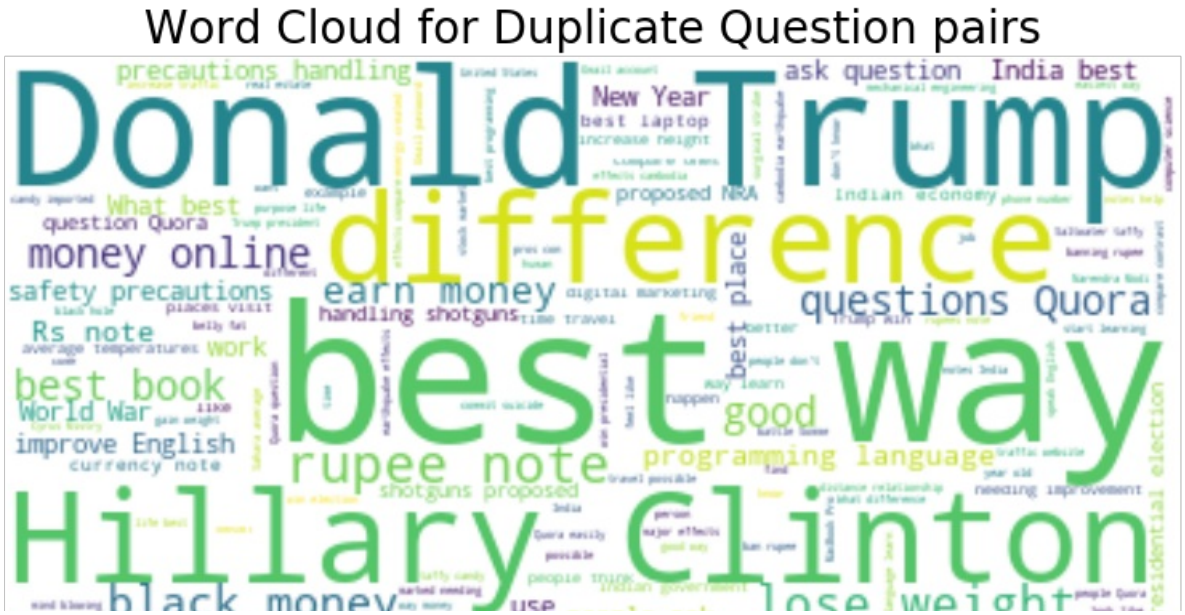
```
df_duplicate = df[df['is_duplicate'] == 1]
df_nonduplicate = df[df['is_duplicate'] == 0]

# 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()

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))

#Saving the np array into a text file
np.savetxt('Jalesh_p.txt', p, delimiter=' ', fmt='%s')
np.savetxt('Jalesh_n.txt', n, delimiter=' ', fmt='%s')

#reading file:
textp_w = open(os.path.join('.', 'Jalesh_p.txt')).read()
textn_w = open(os.path.join('.', 'Jalesh_n.txt')).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))
```

```
Number of data points in class 1 (duplicate pairs) : 298526
Number of data points in class 0 (non duplicate pairs) : 510054
Total number of words in duplicate pair questions : 16087608
Total number of words in non duplicate pair questions : 33092336
```

1. WordCloud

In [39]:

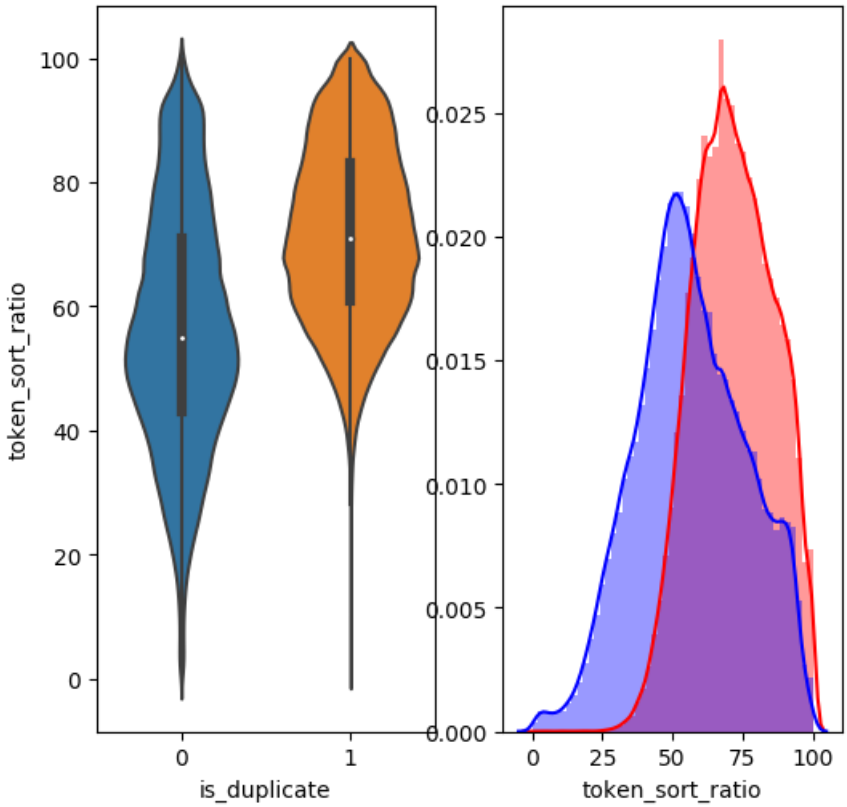
```
plt.figure(figsize=(8,8), dpi=100)
wc = WordCloud(background_color="white", max_words=len(textp_w), stopwords=stopwords)
wc.generate(textp_w)
#print ("Word Cloud for Duplicate Question pairs")
plt.imshow(wc, interpolation='bilinear')
plt.axis("off")
plt.title("Word Cloud for Duplicate Question pairs", color='black', size=20)
plt.tight_layout()
plt.show()
```



2.Violinlot

In [40]:

```
# Distribution of the token_sort_ratio
plt.figure(figsize=(6, 6), dpi=100)

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()
```



3.tSNE

In [41]:

```
#Using TSNE for Dimentionality reduction for 14 Features(Generated after cleaning the data) to 3 d
imention

from sklearn.preprocessing import MinMaxScaler

dfp_subsampled = df[0:500]
X = MinMaxScaler().fit_transform(dfp_subsampled[['cwc_min', 'cwc_max', 'csc_min', 'csc_max' ,
'ctc_min' , 'ctc_max' , 'first_word_eq' , 'abs_len_diff' , 'token_set_ratio' , 'token_sort_ratio' ,
'fuzz_ratio' , 'fuzz_partial_ratio' , 'longest_substr_ratio']])
y = dfp_subsampled['is_duplicate'].values
```

In [42]:

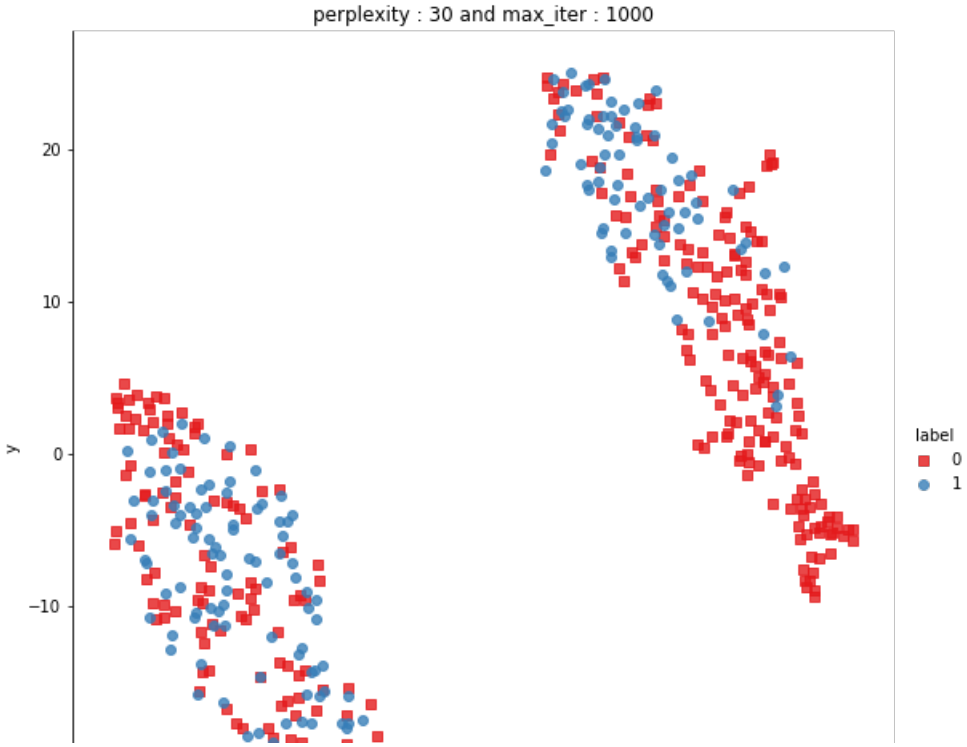
```
from sklearn.manifold import TSNE
tsne2d = TSNE(
    n_components=2,
```

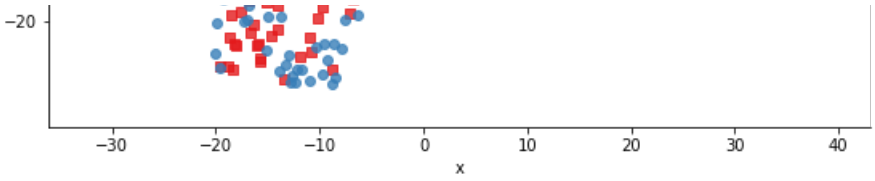
```
    init='random', # pca
    random_state=101,
    method='barnes_hut',
    n_iter=1000,
    verbose=2,
    angle=0.5
).fit_transform(X)
```

```
[t-SNE] Computing 91 nearest neighbors...
[t-SNE] Indexed 500 samples in 0.001s...
[t-SNE] Computed neighbors for 500 samples in 0.017s...
[t-SNE] Computed conditional probabilities for sample 500 / 500
[t-SNE] Mean sigma: 0.215459
[t-SNE] Computed conditional probabilities in 0.034s
[t-SNE] Iteration 50: error = 59.2758102, gradient norm = 0.5010622 (50 iterations in 0.384s)
[t-SNE] Iteration 100: error = 58.6526222, gradient norm = 0.4975067 (50 iterations in 0.381s)
[t-SNE] Iteration 150: error = 58.4290771, gradient norm = 0.5111917 (50 iterations in 0.375s)
[t-SNE] Iteration 200: error = 58.3918343, gradient norm = 0.4965278 (50 iterations in 0.372s)
[t-SNE] Iteration 250: error = 58.1947746, gradient norm = 0.4879106 (50 iterations in 0.377s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 58.194775
[t-SNE] Iteration 300: error = 0.5708505, gradient norm = 0.0015301 (50 iterations in 0.340s)
[t-SNE] Iteration 350: error = 0.5216662, gradient norm = 0.0005339 (50 iterations in 0.326s)
[t-SNE] Iteration 400: error = 0.4860596, gradient norm = 0.0003951 (50 iterations in 0.336s)
[t-SNE] Iteration 450: error = 0.4805854, gradient norm = 0.0002282 (50 iterations in 0.326s)
[t-SNE] Iteration 500: error = 0.4768022, gradient norm = 0.0001947 (50 iterations in 0.327s)
[t-SNE] Iteration 550: error = 0.4739868, gradient norm = 0.0001858 (50 iterations in 0.329s)
[t-SNE] Iteration 600: error = 0.4719697, gradient norm = 0.0001705 (50 iterations in 0.329s)
[t-SNE] Iteration 650: error = 0.4700935, gradient norm = 0.0001667 (50 iterations in 0.329s)
[t-SNE] Iteration 700: error = 0.4690734, gradient norm = 0.0001302 (50 iterations in 0.331s)
[t-SNE] Iteration 750: error = 0.4678034, gradient norm = 0.0001304 (50 iterations in 0.332s)
[t-SNE] Iteration 800: error = 0.4670660, gradient norm = 0.0001406 (50 iterations in 0.334s)
[t-SNE] Iteration 850: error = 0.4661894, gradient norm = 0.0001123 (50 iterations in 0.338s)
[t-SNE] Iteration 900: error = 0.4653809, gradient norm = 0.0001299 (50 iterations in 0.333s)
[t-SNE] Iteration 950: error = 0.4646829, gradient norm = 0.0001028 (50 iterations in 0.334s)
[t-SNE] Iteration 1000: error = 0.4641249, gradient norm = 0.0001186 (50 iterations in 0.335s)
[t-SNE] Error after 1000 iterations: 0.464125
```

In [43]:

```
d = pd.DataFrame({'x':tsne2d[:,0], 'y':tsne2d[:,1] ,'label':y})

# draw the plot in appropriate place in the grid
sns.lmplot(data=d, 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()
```





3.tSNE-3D

In [44]:

```
tsne3d = 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 500 samples in 0.001s...
[t-SNE] Computed neighbors for 500 samples in 0.017s...
[t-SNE] Computed conditional probabilities for sample 500 / 500
[t-SNE] Mean sigma: 0.215459
[t-SNE] Computed conditional probabilities in 0.033s
[t-SNE] Iteration 50: error = 66.8670273, gradient norm = 0.3592659 (50 iterations in 1.159s)
[t-SNE] Iteration 100: error = 73.1500702, gradient norm = 0.3126838 (50 iterations in 1.017s)
[t-SNE] Iteration 150: error = 78.8705215, gradient norm = 0.2922585 (50 iterations in 1.007s)
[t-SNE] Iteration 200: error = 87.0154343, gradient norm = 0.2738982 (50 iterations in 1.014s)
[t-SNE] Iteration 250: error = 87.6179962, gradient norm = 0.2592096 (50 iterations in 0.989s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 87.617996
[t-SNE] Iteration 300: error = 2.4458036, gradient norm = 0.0006620 (50 iterations in 1.145s)
[t-SNE] Iteration 350: error = 2.0095630, gradient norm = 0.0002913 (50 iterations in 1.199s)
[t-SNE] Iteration 400: error = 1.7550094, gradient norm = 0.0001679 (50 iterations in 1.157s)
[t-SNE] Iteration 450: error = 1.6056418, gradient norm = 0.0001094 (50 iterations in 1.158s)
[t-SNE] Iteration 500: error = 1.4960916, gradient norm = 0.0000787 (50 iterations in 1.153s)
[t-SNE] Iteration 550: error = 1.4035016, gradient norm = 0.0000717 (50 iterations in 1.154s)
[t-SNE] Iteration 600: error = 1.3250026, gradient norm = 0.0000586 (50 iterations in 1.151s)
[t-SNE] Iteration 650: error = 1.2709816, gradient norm = 0.0000430 (50 iterations in 1.146s)
[t-SNE] Iteration 700: error = 1.2195649, gradient norm = 0.0000478 (50 iterations in 1.130s)
[t-SNE] Iteration 750: error = 1.1692649, gradient norm = 0.0000405 (50 iterations in 1.106s)
[t-SNE] Iteration 800: error = 1.1191503, gradient norm = 0.0000360 (50 iterations in 1.103s)
[t-SNE] Iteration 850: error = 1.0771393, gradient norm = 0.0000313 (50 iterations in 1.102s)
[t-SNE] Iteration 900: error = 1.0438914, gradient norm = 0.0000233 (50 iterations in 1.094s)
[t-SNE] Iteration 950: error = 1.0171566, gradient norm = 0.0000212 (50 iterations in 1.076s)
[t-SNE] Iteration 1000: error = 0.9912969, gradient norm = 0.0000217 (50 iterations in 1.081s)
[t-SNE] Error after 1000 iterations: 0.991297
```

In [45]:

```
trace1 = go.Scatter3d(
    x=tsne3d[:,0],
    y=tsne3d[:,1],
    z=tsne3d[:,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')
```

Conclusion

1. I have created functional approach in creation of some of the primary features of data frame

2. I have created SPACY in this project for stopwords, punctuation removal, token creation etc.

3. I have plotted heatmap in order to see the correlation amongst features