In [1]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

In [4]:
```
ng\Python\NLP by campus X\quora-question-pairs_only-bow.ipynb at main · campusx-official_quora-question-pairs · GitHub_files\data
```

```
C:\Users\SaquibRahman\OneDrive - TheMathCompany Private Limited\Desktop\Training\Python\NLP by campus X\quora-question-pairs_on
ly-bow.ipynb at main · campusx-official_quora-question-pairs · GitHub_files\data
```

In [5]:
```
df = pd.read_csv("train.csv")
df.shape
```

Out[5]: (404290, 6)

In [6]:
```
df.sample(10)
```

Out[6]:

	id	qid1	qid2	question1	question2	is_duplicate
116556	116556	116583	189843	What are some of the best places in India to v...	What are some of the best places to visit in I...	1
344164	344164	472354	472355	Why does Uranus not orbit anticlockwise like t...	How does the orbit of Uranus look like (from t...	0
341253	341253	469053	119568	*>||<* 1800><251><4919 *>||<* Cisco Router@@Te...	What is cisco router technical support phone n...	0
284183	284183	404379	404380	How do I install a custom Rom in Spice mettle ...	How do I install a custom ROM in my rooted phone?	0
120771	120771	195843	195844	How does MeetMe define their target market?	How does Twitter define their target market?	0
46062	46062	18952	82436	How do I gain weight?	What is the best way for underweight to gain w...	1
183260	183260	42810	31229	What is actual meaning of life?	What is the meaning of this life?	1
393906	393906	526744	526745	Is it illegal for a 19 dating a 15?	I'm 36 year old man and in love with a 19 year...	0
60705	60705	106123	30782	Porn Stars: Where is Shy Love now?	How can you look at someone's private Instagra...	0
196121	196121	296759	296760	What are the health benefits of darjeeling tea?	What are the health benefits of drinking Darje...	1

In [7]:
```
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 [8]:
```
# missing values
df.isnull().sum()
```

Out[8]:
```
id              0
qid1            0
qid2            0
question1       1
question2       2
is_duplicate    0
dtype: int64
```

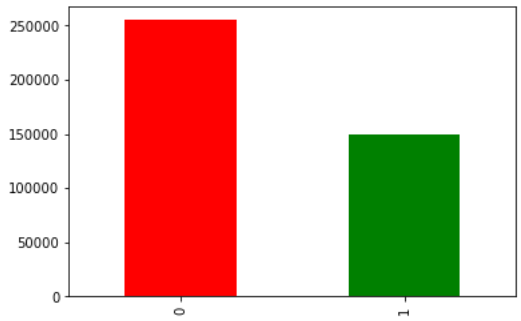
In [9]:
```
# duplicate rows
df.duplicated().sum()
```

Out[9]: 0

In [11]:
```
# Distribution of duplicate and non-duplicate questions
c= ['red', 'green']
print(df['is_duplicate'].value_counts())
print((df['is_duplicate'].value_counts()/df['is_duplicate'].count())*100)
df['is_duplicate'].value_counts().plot(kind='bar', color = c)
```

```
0    255027
1    149263
Name: is_duplicate, dtype: int64
0    63.080215
1    36.919785
Name: is_duplicate, dtype: float64
```

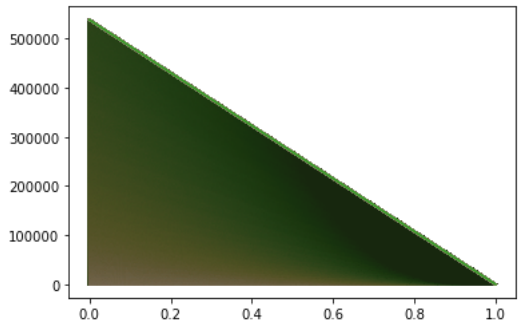
Out[11]: <AxesSubplot:>



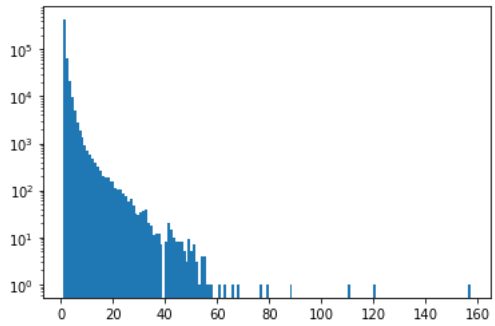
In [69]:
```
# Repeated questions

qid = pd.Series(df['qid1'].tolist() + df['qid2'].tolist())
print('Number of unique questions',np.unique(qid).shape[0])
x = qid.value_counts()>1
print('Number of questions getting repeated',x[x].shape[0])
```

```
Number of unique questions 537933
Number of questions getting repeated 111780
```

In [85]:
```
# a = np.unique(qid)
# lst = list(np.unique(a, return_counts=True))
# plt.plot(lst)
# plt.show()
```



In [13]:
```
# Repeated questions histogram

plt.hist(qid.value_counts().values,bins=160)
plt.yscale('log')
plt.show()
```



using bag of words

In [15]:
```
new_df = df.sample(30000)
```

In [16]:
```
new_df.isnull().sum()
```

Out[16]:
```
id              0
qid1            0
qid2            0
question1       0
question2       0
is_duplicate    0
dtype: int64
```

In [17]:
```
new_df.duplicated().sum()
```

Out[17]:
```
0
```

In [18]:
```
ques_df = new_df[['question1','question2']]
ques_df.head()
```

Out[18]:

	question1	question2
212317	Why do some educated people in developed count...	Why do people join ISIS?
376657	Can you be an atheist but believe in ghosts?	Is it justified for an atheist to believe in g...
278723	Why do some people have sweaty hands all the t...	Why do some people have sweaty palms?
382943	How do I approach a girl for sex?	What is the best way to approach a girl?
198249	What are some affordable tax law firms in Kara...	What are some affordable tax law firms?

count vectorizer!

In [20]:
```
from sklearn.feature_extraction.text import CountVectorizer
# merge texts
questions = list(ques_df['question1']) + list(ques_df['question2'])

cv = CountVectorizer(max_features=3000)
q1_arr, q2_arr = np.vsplit(cv.fit_transform(questions).toarray(),2)
```

In [22]:
```
temp_df1 = pd.DataFrame(q1_arr, index= ques_df.index)
temp_df2 = pd.DataFrame(q2_arr, index= ques_df.index)
temp_df = pd.concat([temp_df1, temp_df2], axis=1)
temp_df.shape
```

Out[22]:
```
(30000, 6000)
```

In [24]:
```
temp_df['is_duplicate'] = new_df['is_duplicate']
```

In [25]:
```
temp_df
```

Out[25]:

	0	1	2	3	4	5	6	7	8	9	...	2991	2992	2993	2994	2995	2996	2997	2998	2999	is_duplicate
212317	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
376657	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	1
278723	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	1
382943	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
198249	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
106526	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	1
91946	0	0	0	0	0	0	0	0	0	0	...	1	0	0	0	0	0	0	0	0	0
164002	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
60972	0	0	0	0	0	0	0	0	0	0	...	3	0	0	1	0	0	0	0	0	0
342272	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

30000 rows × 6001 columns

In [26]:
```
from sklearn.model_selection import train_test_split

X_train,X_test,y_train,y_test = train_test_split(temp_df.iloc[:,0:-1].values,temp_df.iloc[:,-1].values,test_size=0.2,random_
```

random forest & xgboost and lightbgm

In [27]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
rf = RandomForestClassifier()
rf.fit(X_train,y_train)
y_pred = rf.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[27]: 0.736

In [29]:
```
from xgboost import XGBClassifier
xgb = XGBClassifier()
xgb.fit(X_train,y_train)
y_pred = xgb.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[29]: 0.7376666666666667

In [30]:
```
from lightgbm import LGBMClassifier
lgb = LGBMClassifier()
lgb.fit(X_train,y_train)
y_pred = lgb.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[30]: 0.7348333333333333

BOW with basic feature engineering

In [31]:
```
import warnings
warnings.filterwarnings('ignore')
```

In [37]:
```
new_df = df.sample(30000,random_state=2)
new_df
```

Out[37]:

	id	qid1	qid2	question1	question2	is_duplicate
398782	398782	496695	532029	What is the best marketing automation tool for...	What is the best marketing automation tool for...	1
115086	115086	187729	187730	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...	0
327711	327711	454161	454162	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...	0
367788	367788	498109	491396	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...	0
151235	151235	237843	50930	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...	0
...	...	...	...	...	...	...
243932	243932	26193	356455	What are some good web scraping tutorials?	What are some good web scraping programs?	1
91980	91980	154063	154064	Can I apply for internet banking in SBI withou...	I have internet banking kit of SBI but it's no...	0
266955	266955	133017	384210	How much HE laundry detergent do you use in a ...	Can I use regular Dawn dishsoap in my dishwash...	0
71112	71112	122427	122428	What is the best way to understand and learn m...	What are some of the best ways to learn math?	1
312470	312470	436915	436916	What would the Modi-led government do in case ...	If Pakistan mounts a 26/11 type attack again, ...	1

30000 rows × 6 columns

In [35]:
```
new_df.isnull().sum()
```

Out[35]:
```
id              0
qid1            0
qid2            0
question1       0
question2       0
is_duplicate    0
dtype: int64
```

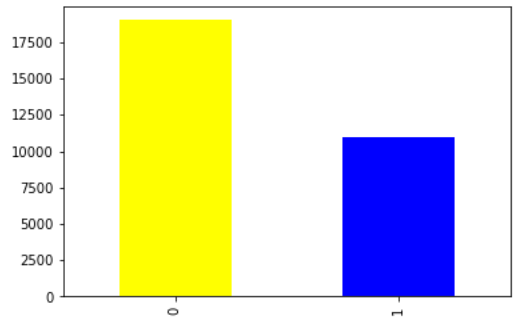
In [38]:
```
new_df.duplicated().sum()
```

Out[38]: 0

In [40]:
```
# Distribution of duplicate and non-duplicate questions
c= ['yellow', 'blue']
print(new_df['is_duplicate'].value_counts())
print((new_df['is_duplicate'].value_counts()/new_df['is_duplicate'].count())*100)
new_df['is_duplicate'].value_counts().plot(kind='bar', color =c)
```

```
0    19013
1    10987
Name: is_duplicate, dtype: int64
0    63.376667
1    36.623333
Name: is_duplicate, dtype: float64
```

Out[40]: <AxesSubplot:>



In [41]:
```
# Repeated questions

qid = pd.Series(new_df['qid1'].tolist() + new_df['qid2'].tolist())
print('Number of unique questions',np.unique(qid).shape[0])
x = qid.value_counts()>1
print('Number of questions getting repeated',x[x].shape[0])
```

```
Number of unique questions 55299
Number of questions getting repeated 3480
```

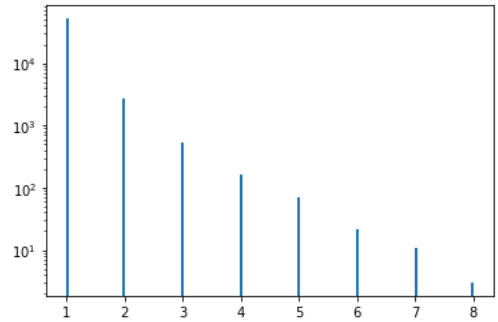
In [88]:
```
qid
```

Out[88]:
```
0              1
1              3
2              5
3              7
4              9
           ...
808575    379845
808576    155606
808577    537929
808578    537931
808579    537933
Length: 808580, dtype: int64
```

In [87]:
```
55299+3480
```

Out[87]: 58779

In [42]:
```
# Repeated questions histogram

plt.hist(qid.value_counts().values,bins=160)
plt.yscale('log')
plt.show()
```



In [43]:
```
# Feature Engineering

new_df['q1_len'] = new_df['question1'].str.len()
new_df['q2_len'] = new_df['question2'].str.len()
```

In [44]:
```
new_df.head()
```

Out[44]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len
398782	398782	496695	532029	What is the best marketing automation tool for...	What is the best marketing automation tool for...	1	76	77
115086	115086	187729	187730	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...	0	49	57
327711	327711	454161	454162	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...	0	105	120
367788	367788	498109	491396	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...	0	59	146
151235	151235	237843	50930	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...	0	35	50

In [45]:
```
new_df['q1_num_words'] = new_df['question1'].apply(lambda row: len(row.split(" ")))
new_df['q2_num_words'] = new_df['question2'].apply(lambda row: len(row.split(" ")))
new_df.head()
```

Out[45]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words
398782	398782	496695	532029	What is the best marketing automation tool for...	What is the best marketing automation tool for...	1	76	77	12	12
115086	115086	187729	187730	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...	0	49	57	12	15
327711	327711	454161	454162	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...	0	105	120	25	17
367788	367788	498109	491396	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...	0	59	146	12	30
151235	151235	237843	50930	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...	0	35	50	5	9

In [46]:
```
def common_words(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return len(w1 & w2)
```

In [47]:
```
new_df['word_common'] = new_df.apply(common_words, axis=1)
new_df.head()
```

Out[47]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common
398782	398782	496695	532029	What is the best marketing automation tool for...	What is the best marketing automation tool for...	1	76	77	12	12	11
115086	115086	187729	187730	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...	0	49	57	12	15	7
327711	327711	454161	454162	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...	0	105	120	25	17	2
367788	367788	498109	491396	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...	0	59	146	12	30	0
151235	151235	237843	50930	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...	0	35	50	5	9	3

In [93]:
```
def total_words(row):
    w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
    return (len(w1) + len(w2))
    print(len(w1))
```

In [49]:
```
new_df['word_total'] = new_df.apply(total_words, axis=1)
new_df.head()
```

Out[49]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total
398782	398782	496695	532029	What is the best marketing automation tool for...	What is the best marketing automation tool for...	1	76	77	12	12	11	24
115086	115086	187729	187730	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...	0	49	57	12	15	7	23
327711	327711	454161	454162	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...	0	105	120	25	17	2	34
367788	367788	498109	491396	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...	0	59	146	12	30	0	32
151235	151235	237843	50930	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...	0	35	50	5	9	3	13

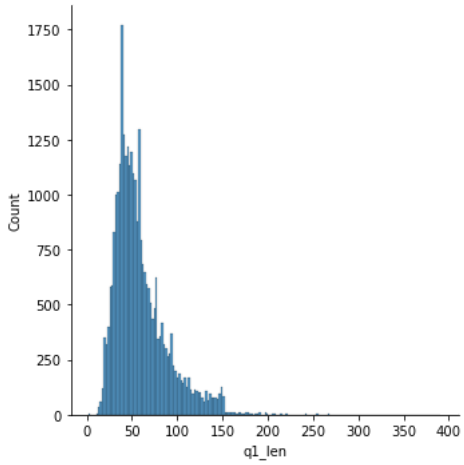
In [50]:
```
new_df['word_share'] = round(new_df['word_common']/new_df['word_total'],2)
new_df.head()
```

Out[50]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total	word_shar
398782	398782	496695	532029	What is the best marketing automation tool for...	What is the best marketing automation tool for...	1	76	77	12	12	11	24	0.4
115086	115086	187729	187730	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...	0	49	57	12	15	7	23	0.3
327711	327711	454161	454162	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...	0	105	120	25	17	2	34	0.0
367788	367788	498109	491396	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...	0	59	146	12	30	0	32	0.0
151235	151235	237843	50930	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...	0	35	50	5	9	3	13	0.2

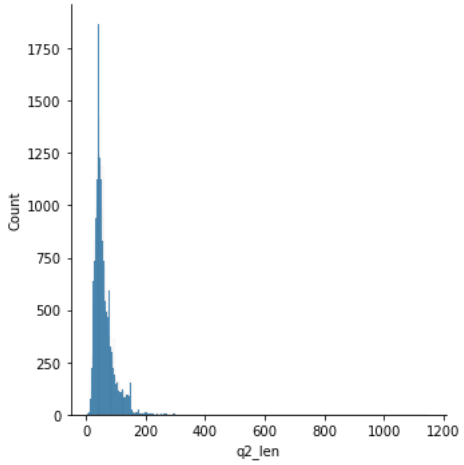
In [51]:
```
# Analysis of features
sns.displot(new_df['q1_len'])
print('minimum characters',new_df['q1_len'].min())
print('maximum characters',new_df['q1_len'].max())
print('average num of characters',int(new_df['q1_len'].mean()))
```

```
minimum characters 2
maximum characters 391
average num of characters 59
```



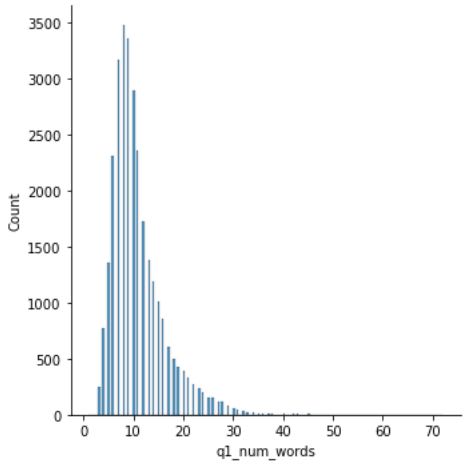
In [52]:
```
sns.displot(new_df['q2_len'])
print('minimum characters',new_df['q2_len'].min())
print('maximum characters',new_df['q2_len'].max())
print('average num of characters',int(new_df['q2_len'].mean()))
```

```
minimum characters 6
maximum characters 1151
average num of characters 60
```



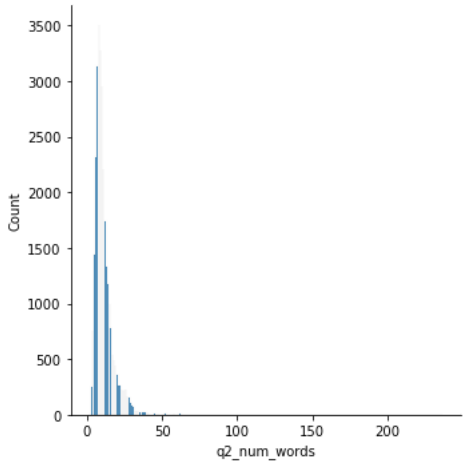
In [53]:
```
sns.displot(new_df['q1_num_words'])
print('minimum words',new_df['q1_num_words'].min())
print('maximum words',new_df['q1_num_words'].max())
print('average num of words',int(new_df['q1_num_words'].mean()))
```

```
minimum words 1
maximum words 72
average num of words 10
```

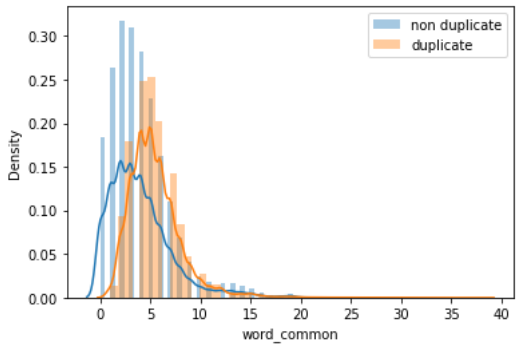


In [54]:
```
sns.displot(new_df['q2_num_words'])
print('minimum words',new_df['q2_num_words'].min())
print('maximum words',new_df['q2_num_words'].max())
print('average num of words',int(new_df['q2_num_words'].mean()))
```

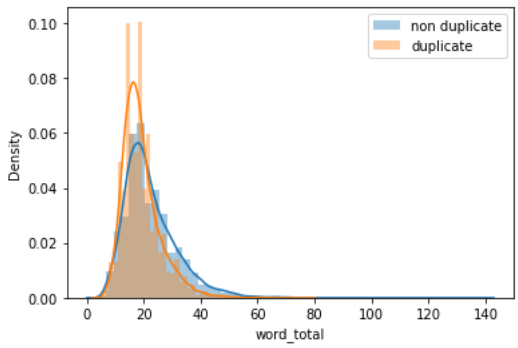
```
minimum words 1
maximum words 237
average num of words 11
```



In [55]:
```
# common words
sns.distplot(new_df[new_df['is_duplicate'] == 0]['word_common'],label='non duplicate')
sns.distplot(new_df[new_df['is_duplicate'] == 1]['word_common'],label='duplicate')
plt.legend()
plt.show()
```



In [56]:
```
# total words
sns.distplot(new_df[new_df['is_duplicate'] == 0]['word_total'],label='non duplicate')
sns.distplot(new_df[new_df['is_duplicate'] == 1]['word_total'],label='duplicate')
plt.legend()
plt.show()
```



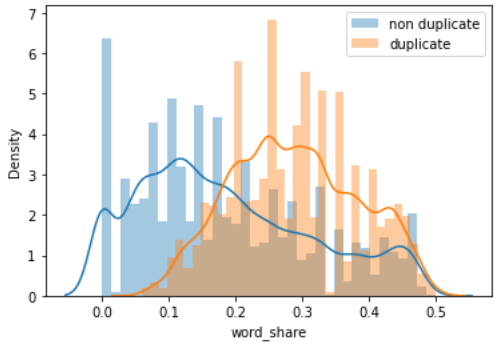
In [108]:
```
new_df[new_df['is_duplicate'] == 0]['word_total'][:5]
```

Out[108]:
```
115086    23
327711    34
367788    32
151235    13
244531    25
Name: word_total, dtype: int64
```

In [109]:
```
new_df[new_df['is_duplicate'] == 0]['word_common'][:5]
```

Out[109]:
```
115086    7
327711    2
367788    0
151235    3
244531    1
Name: word_common, dtype: int64
```

In [57]:
```
# word share
sns.distplot(new_df[new_df['is_duplicate'] == 0]['word_share'],label='non duplicate')
sns.distplot(new_df[new_df['is_duplicate'] == 1]['word_share'],label='duplicate')
plt.legend()
plt.show()
```



In [58]:
```
ques_df = new_df[['question1','question2']]
ques_df.head()
```

Out[58]:

	question1	question2
398782	What is the best marketing automation tool for...	What is the best marketing automation tool for...
115086	I am poor but I want to invest. What should I do?	I am quite poor and I want to be very rich. Wh...
327711	I am from India and live abroad. I met a guy f...	T.I.E.T to Thapar University to Thapar Univers...
367788	Why do so many people in the U.S. hate the sou...	My boyfriend doesnt feel guilty when he hurts ...
151235	Consequences of Bhopal gas tragedy?	What was the reason behind the Bhopal gas trag...

In [59]:
```
final_df = new_df.drop(columns=['id','qid1','qid2','question1','question2'])
print(final_df.shape)
final_df.head()
```

```
(30000, 8)
```

Out[59]:

	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total	word_share
398782	1	76	77	12	12	11	24	0.46
115086	0	49	57	12	15	7	23	0.30
327711	0	105	120	25	17	2	34	0.06
367788	0	59	146	12	30	0	32	0.00
151235	0	35	50	5	9	3	13	0.23

In [60]:
```
from sklearn.feature_extraction.text import CountVectorizer
# merge texts
questions = list(ques_df['question1']) + list(ques_df['question2'])

cv = CountVectorizer(max_features=3000)
q1_arr, q2_arr = np.vsplit(cv.fit_transform(questions).toarray(),2)
```

In [61]:
```
temp_df1 = pd.DataFrame(q1_arr, index= ques_df.index)
temp_df2 = pd.DataFrame(q2_arr, index= ques_df.index)
temp_df = pd.concat([temp_df1, temp_df2], axis=1)
temp_df.shape
```

Out[61]: (30000, 6000)

In [62]:
```
final_df = pd.concat([final_df, temp_df], axis=1)
print(final_df.shape)
final_df.head()
```

```
(30000, 6008)
```

Out[62]:

	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total	word_share	0	1	...	2990	2991	2992	2993	2994	2995	29
398782	1	76	77	12	12	11	24	0.46	0	0	...	0	0	0	0	0	0	
115086	0	49	57	12	15	7	23	0.30	0	0	...	0	0	0	0	0	0	
327711	0	105	120	25	17	2	34	0.06	0	0	...	0	0	0	0	0	0	
367788	0	59	146	12	30	0	32	0.00	0	0	...	0	0	0	1	0	0	
151235	0	35	50	5	9	3	13	0.23	0	0	...	0	0	0	0	0	0	

5 rows × 6008 columns

In [63]:
```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(final_df.iloc[:,1:].values,final_df.iloc[:,0].values,test_size=0.2,random_s
```

In [64]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
rf = RandomForestClassifier()
rf.fit(X_train,y_train)
y_pred = rf.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[64]: 0.77

In [65]:
```
from xgboost import XGBClassifier
xgb = XGBClassifier()
xgb.fit(X_train,y_train)
y_pred = xgb.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[65]: 0.7645

In [66]:
```
from lightgbm import LGBMClassifier
lgb = LGBMClassifier()
lgb.fit(X_train,y_train)
y_pred = lgb.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[66]: 0.7691666666666667

advance feature engineering!

In [110]:
```
# <!--
# 1. Token Features
# cwc_min: This is the ratio of the number of common words to the length of the smaller question
# cwc_max: This is the ratio of the number of common words to the length of the larger question
# csc_min: This is the ratio of the number of common stop words to the smaller stop word count among the two questions
# csc_max: This is the ratio of the number of common stop words to the larger stop word count among the two questions
# ctc_min: This is the ratio of the number of common tokens to the smaller token count among the two questions
# ctc_max: This is the ratio of the number of common tokens to the larger token count among the two questions
# last_word_eq: 1 if the last word in the two questions is same, 0 otherwise
# first_word_eq: 1 if the first word in the two questions is same, 0 otherwise

# 2. Length Based Features
# mean_len: Mean of the length of the two questions (number of words)
# abs_len_diff: Absolute difference between the length of the two questions (number of words)
# longest_substr_ratio: Ratio of the length of the longest substring among the two questions to the length of the smaller qu

# 3. Fuzzy Features
# fuzz_ratio: fuzz_ratio score from fuzzywuzzy
# fuzz_partial_ratio: fuzz_partial_ratio from fuzzywuzzy
# token_sort_ratio: token_sort_ratio from fuzzywuzzy
# token_set_ratio: token_set_ratio from fuzzywuzzy --> -->
```

In [116]:
```
import re
from bs4 import BeautifulSoup

import warnings
warnings.filterwarnings('ignore')
```

In [115]:
```
new_df =df.sample(30000, random_state=1)
new_df.head()
```

Out[115]:

	id	qid1	qid2	question1	question2	is_duplicate
237030	237030	33086	348102	How can I stop playing video games?	Should I stop playing video games with my child?	0
247341	247341	73272	8624	Who is better Donald Trump or Hillary Clinton?	Why is Hillary Clinton a better choice than Do...	1
246425	246425	359482	359483	What do you think is the chance that sometime ...	Do you think there will be another world war/n...	1
306985	306985	1357	47020	Why are so many questions posted to Quora that...	Why do people write questions on Quora that co...	1
225863	225863	334315	334316	Can there even be a movie ever rated 10/10 on ...	What are your 10/10 movies?	0

In [146]:
```
new_df.nunique()
```

Out[146]:
```
id                    30000
qid1                  28408
qid2                  28335
question1             28389
question2             28311
is_duplicate              2
q1_len                  248
q2_len                  281
q1_num_words             64
q2_num_words             79
word_common              30
word_total               75
word_share               50
cwc_min                 125
cwc_max                 197
csc_min                 118
csc_max                 207
ctc_min                 410
ctc_max                 652
last_word_eq              2
first_word_eq             2
abs_len_diff             52
mean_len                 98
longest_substr_ratio   2645
fuzz_ratio              101
fuzz_partial_ratio       92
token_sort_ratio        101
token_set_ratio          98
dtype: int64
```

In [117]:

```
def preprocess(q):

    q = str(q).lower().strip()

    # Replace certain special characters with their string equivalents
    q = q.replace('%', ' percent')
    q = q.replace('$', ' dollar ')
    q = q.replace('₹', ' rupee ')
    q = q.replace('€', ' euro ')
    q = q.replace('@', ' at ')

    # The pattern '[math]' appears around 900 times in the whole dataset.
    q = q.replace('[math]', '')

    # Replacing some numbers with string equivalents (not perfect, can be done better to account for more cases)
    q = q.replace(',000,000,000 ', 'b ')
    q = q.replace(',000,000 ', 'm ')
    q = q.replace(',000 ', 'k ')
    q = re.sub(r'([0-9]+)000000000', r'\1b', q)
    q = re.sub(r'([0-9]+)000000', r'\1m', q)
    q = re.sub(r'([0-9]+)000', r'\1k', q)

    # Decontracting words
    # https://en.wikipedia.org/wiki/Wikipedia%3aList_of_English_contractions
    # https://stackoverflow.com/a/19794953
    contractions = {
    "ain't": "am not",
    "aren't": "are not",
    "can't": "can not",
    "can't've": "can not have",
    "'cause": "because",
    "could've": "could have",
    "couldn't": "could not",
    "couldn't've": "could not have",
    "didn't": "did not",
    "doesn't": "does not",
    "don't": "do not",
    "hadn't": "had not",
    "hadn't've": "had not have",
    "hasn't": "has not",
    "haven't": "have not",
    "he'd": "he would",
    "he'd've": "he would have",
    "he'll": "he will",
    "he'll've": "he will have",
    "he's": "he is",
    "how'd": "how did",
    "how'd'y": "how do you",
    "how'll": "how will",
    "how's": "how is",
    "i'd": "i would",
    "i'd've": "i would have",
    "i'll": "i will",
    "i'll've": "i will have",
    "i'm": "i am",
    "i've": "i have",
    "isn't": "is not",
    "it'd": "it would",
    "it'd've": "it would have",
    "it'll": "it will",
    "it'll've": "it will have",
    "it's": "it is",
    "let's": "let us",
    "ma'am": "madam",
    "mayn't": "may not",
    "might've": "might have",
    "mightn't": "might not",
    "mightn't've": "might not have",
    "must've": "must have",
    "mustn't": "must not",
    "mustn't've": "must not have",
    "needn't": "need not",
    "needn't've": "need not have",
    "o'clock": "of the clock",
    "oughtn't": "ought not",
    "oughtn't've": "ought not have",
    "shan't": "shall not",
    "sha'n't": "shall not",
    "shan't've": "shall not have",
    "she'd": "she would",
    "she'd've": "she would have",
    "she'll": "she will",
    "she'll've": "she will have",
    "she's": "she is",
    "should've": "should have",
    "shouldn't": "should not",
```

```
    "shouldn't've": "should not have",
    "so've": "so have",
    "so's": "so as",
    "that'd": "that would",
    "that'd've": "that would have",
    "that's": "that is",
    "there'd": "there would",
    "there'd've": "there would have",
    "there's": "there is",
    "they'd": "they would",
    "they'd've": "they would have",
    "they'll": "they will",
    "they'll've": "they will have",
    "they're": "they are",
    "they've": "they have",
    "to've": "to have",
    "wasn't": "was not",
    "we'd": "we would",
    "we'd've": "we would have",
    "we'll": "we will",
    "we'll've": "we will have",
    "we're": "we are",
    "we've": "we have",
    "weren't": "were not",
    "what'll": "what will",
    "what'll've": "what will have",
    "what're": "what are",
    "what's": "what is",
    "what've": "what have",
    "when's": "when is",
    "when've": "when have",
    "where'd": "where did",
    "where's": "where is",
    "where've": "where have",
    "who'll": "who will",
    "who'll've": "who will have",
    "who's": "who is",
    "who've": "who have",
    "why's": "why is",
    "why've": "why have",
    "will've": "will have",
    "won't": "will not",
    "won't've": "will not have",
    "would've": "would have",
    "wouldn't": "would not",
    "wouldn't've": "would not have",
    "y'all": "you all",
    "y'all'd": "you all would",
    "y'all'd've": "you all would have",
    "y'all're": "you all are",
    "y'all've": "you all have",
    "you'd": "you would",
    "you'd've": "you would have",
    "you'll": "you will",
    "you'll've": "you will have",
    "you're": "you are",
    "you've": "you have"
    }

    q_decontracted = []

    for word in q.split():
        if word in contractions:
            word = contractions[word]

        q_decontracted.append(word)

    q = ' '.join(q_decontracted)
    q = q.replace("'ve", " have")
    q = q.replace("n't", " not")
    q = q.replace("'re", " are")
    q = q.replace("'ll", " will")

    # Removing HTML tags
    q = BeautifulSoup(q)
    q = q.get_text()

    # Remove punctuations
    pattern = re.compile('\W')
    q = re.sub(pattern, ' ', q).strip()


    return q
```

In [ ]:
```
1
```

In [118]:
```
1 preprocess("I've already! wasn't <b>done</b>?")
```

Out[118]:
```
'i have already  was not done'
```

In [119]:
```
1 new_df['question1'] = new_df['question1'].apply(preprocess)
2 new_df['question2'] = new_df['question2'].apply(preprocess)
```

In [120]:
```
1 new_df.head()
```

Out[120]:

	id	qid1	qid2	question1	question2	is_duplicate
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0

In [121]:
```
1 new_df['q1_len'] = new_df['question1'].str.len()
2 new_df['q2_len'] = new_df['question2'].str.len()
```

In [122]:
```
1 new_df['q1_num_words'] = new_df['question1'].apply(lambda row: len(row.split(" ")))
2 new_df['q2_num_words'] = new_df['question2'].apply(lambda row: len(row.split(" ")))
3 new_df.head()
```

Out[122]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6

In [123]:
```
1 def common_words(row):
2     w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
3     w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
4     return len(w1 & w2)
```

In [124]:
```
1 new_df['word_common'] = new_df.apply(common_words, axis=1)
2 new_df.head()
```

Out[124]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9	5
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10	6
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15	13
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16	5
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6	1

In [125]:
```
1 def total_words(row):
2     w1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" ")))
3     w2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" ")))
4     return (len(w1) + len(w2))
```

In [126]:
```
new_df['word_total'] = new_df.apply(total_words, axis=1)
new_df.head()
```

Out[126]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9	5	16
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10	6	18
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15	13	40
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16	5	30
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6	1	16

In [127]:
```
new_df['word_share'] = round(new_df['word_common']/new_df['word_total'],2)
new_df.head()

```

Out[127]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total	word_share
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9	5	16	0.31
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10	6	18	0.33
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15	13	40	0.32
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16	5	30	0.17
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6	1	16	0.06

In [128]:

```python
# Advanced Features
from nltk.corpus import stopwords

def fetch_token_features(row):

    q1 = row['question1']
    q2 = row['question2']

    SAFE_DIV = 0.0001

    STOP_WORDS = stopwords.words("english")

    token_features = [0.0]*8

    # 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)

    # 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])

    return token_features
```

In [129]:

```python
token_features = new_df.apply(fetch_token_features, axis=1)

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

In [130]:
```
1 new_df
```

Out[130]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	...	word_total	word_share	cwc_min	cw
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9	...	16	0.31	0.999975	0
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10	...	18	0.33	0.999980	0
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15	...	40	0.32	0.857131	0
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16	...	30	0.17	0.374995	0
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6	...	16	0.06	0.499975	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
298455	298455	88357	148625	why is donald trump still ducking his income...	why does not trump begin speaking the truth ...	1	63	74	13	15	...	26	0.19	0.285710	0
16366	16366	31205	31206	how often do women get wet when they see a rea...	how often do women initiate a conversation wit...	0	57	90	13	17	...	29	0.28	0.499994	0
379818	379818	11786	511366	how do i disable voice data for text to speec...	how do i convert call center recordings into t...	0	72	148	15	28	...	42	0.17	0.428565	0
54795	54795	96691	96692	how does mildew form on carpets	how can you prevent mildew from forming on car...	0	31	50	6	9	...	15	0.27	0.666644	0
335036	335036	462289	462290	how do i leave a legacy	how do you leave a legacy to your children	0	23	42	6	9	...	15	0.33	0.999950	0

30000 rows × 21 columns

In [133]:
```
1 # !pip install distance
```

In [134]:
```
import distance

def fetch_length_features(row):

    q1 = row['question1']
    q2 = row['question2']

    length_features = [0.0]*3

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

    if len(q1_tokens) == 0 or len(q2_tokens) == 0:
        return length_features

    # Absolute Length features
    length_features[0] = abs(len(q1_tokens) - len(q2_tokens))

    #Average Token Length of both Questions
    length_features[1] = (len(q1_tokens) + len(q2_tokens))/2

    strs = list(distance.lcsubstrings(q1, q2))
    length_features[2] = len(strs[0]) / (min(len(q1), len(q2)) + 1)

    return length_features

```

In [135]:
```
length_features = new_df.apply(fetch_length_features, axis=1)

new_df['abs_len_diff'] = list(map(lambda x: x[0], length_features))
new_df['mean_len'] = list(map(lambda x: x[1], length_features))
new_df['longest_substr_ratio'] = list(map(lambda x: x[2], length_features))
```

In [136]:
```
new_df.head()
```

Out[136]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	...	cwc_max	csc_min	csc_max	ctc_mi
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9	...	0.799984	0.333322	0.249994	0.71427
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10	...	0.833319	0.333322	0.249994	0.74999
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15	...	0.499996	0.999986	0.538457	0.86666
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16	...	0.333330	0.333328	0.285710	0.31249
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6	...	0.166664	0.000000	0.000000	0.16666

5 rows × 24 columns

In [139]:
```
# !pip install fuzzywuzzy
```

In [140]:
```
# Fuzzy Features
from fuzzywuzzy import fuzz

def fetch_fuzzy_features(row):

    q1 = row['question1']
    q2 = row['question2']

    fuzzy_features = [0.0]*4

    # fuzz_ratio
    fuzzy_features[0] = fuzz.QRatio(q1, q2)

    # fuzz_partial_ratio
    fuzzy_features[1] = fuzz.partial_ratio(q1, q2)

    # token_sort_ratio
    fuzzy_features[2] = fuzz.token_sort_ratio(q1, q2)

    # token_set_ratio
    fuzzy_features[3] = fuzz.token_set_ratio(q1, q2)

    return fuzzy_features
```

In [141]:
```
fuzzy_features = new_df.apply(fetch_fuzzy_features, axis=1)

# Creating new feature columns for fuzzy features
new_df['fuzz_ratio'] = list(map(lambda x: x[0], fuzzy_features))
new_df['fuzz_partial_ratio'] = list(map(lambda x: x[1], fuzzy_features))
new_df['token_sort_ratio'] = list(map(lambda x: x[2], fuzzy_features))
new_df['token_set_ratio'] = list(map(lambda x: x[3], fuzzy_features))
```

In [142]:
```
print(new_df.shape)
new_df.head()
```

```
(30000, 28)
```

Out[142]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	...	ctc_max	last_word_eq	first_word_eq
237030	237030	33086	348102	how can i stop playing video games	should i stop playing video games with my child	0	34	47	7	9	...	0.555549	0.0	0.0
247341	247341	73272	8624	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...	1	45	56	8	10	...	0.599994	0.0	0.0
246425	246425	359482	359483	what do you think is the chance that sometime ...	do you think there will be another world war n...	1	137	76	29	15	...	0.464284	0.0	0.0
306985	306985	1357	47020	why are so many questions posted to quora that...	why do people write questions on quora that co...	1	85	85	16	16	...	0.312498	0.0	1.0
225863	225863	334315	334316	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies	0	50	26	12	6	...	0.083333	0.0	0.0

5 rows × 28 columns

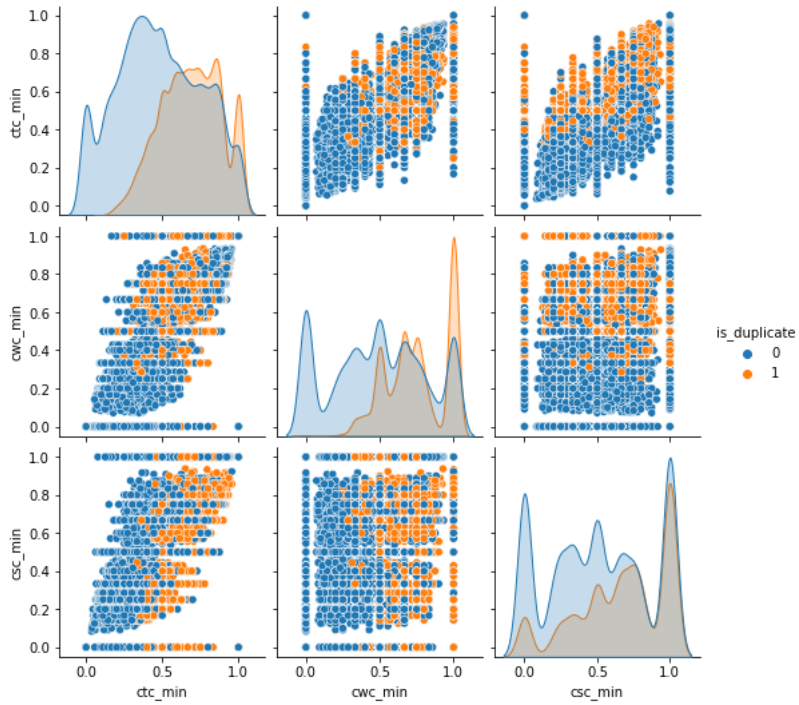
In [143]:
```
1 new_df
```

Out[143]:

...um_words	...	ctc_max	last_word_eq	first_word_eq	abs_len_diff	mean_len	longest_substr_ratio	fuzz_ratio	fuzz_partial_ratio	token_sort_ratio	token_set_ratio
9	...	0.555549	0.0	0.0	2.0	8.0	0.771429	72	85	69	87
10	...	0.599994	0.0	0.0	2.0	9.0	0.347826	42	49	83	92
15	...	0.464284	0.0	0.0	13.0	21.5	0.298701	46	55	70	94
16	...	0.312498	0.0	1.0	0.0	16.0	0.139535	53	53	51	59
6	...	0.083333	0.0	0.0	6.0	9.0	0.259259	42	46	50	46
...	...	...	...	...	...	...	...	...	...	...	...
15	...	0.307690	0.0	1.0	2.0	12.0	0.171875	53	46	50	53
17	...	0.470585	0.0	1.0	4.0	15.0	0.327586	59	58	61	77
28	...	0.222221	0.0	1.0	14.0	20.0	0.123288	31	40	41	53
9	...	0.444440	1.0	1.0	3.0	7.5	0.343750	72	74	64	81
9	...	0.555549	0.0	1.0	3.0	7.5	0.625000	68	87	65	95

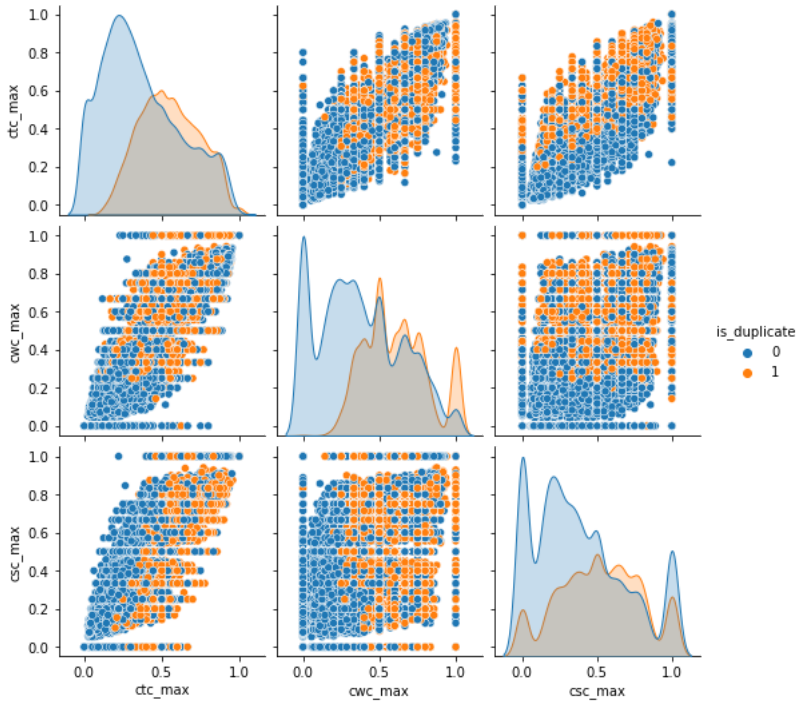
In [153]:
```
sns.pairplot(new_df[['ctc_min', 'cwc_min', 'csc_min', 'is_duplicate']],hue='is_duplicate')
```

Out[153]: <seaborn.axisgrid.PairGrid at 0x18704e6a850>



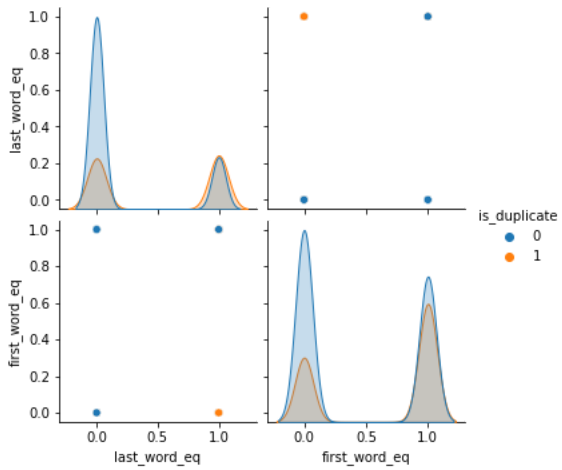
In [154]:
```
sns.pairplot(new_df[['ctc_max', 'cwc_max', 'csc_max', 'is_duplicate']],hue='is_duplicate')
```

Out[154]: <seaborn.axisgrid.PairGrid at 0x18705597220>



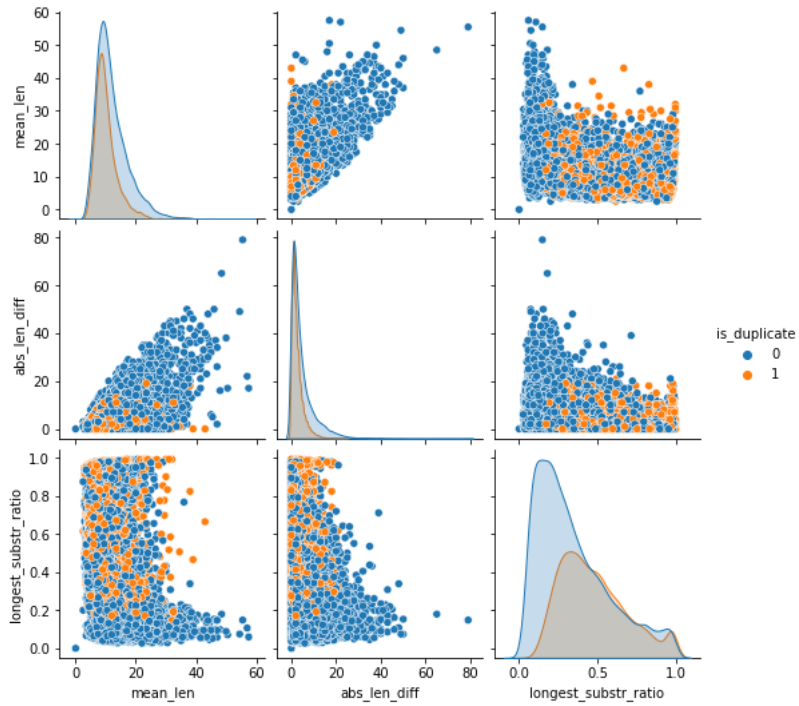
In [155]:
```
sns.pairplot(new_df[['last_word_eq', 'first_word_eq', 'is_duplicate']],hue='is_duplicate')
```

Out[155]: <seaborn.axisgrid.PairGrid at 0x187073538e0>



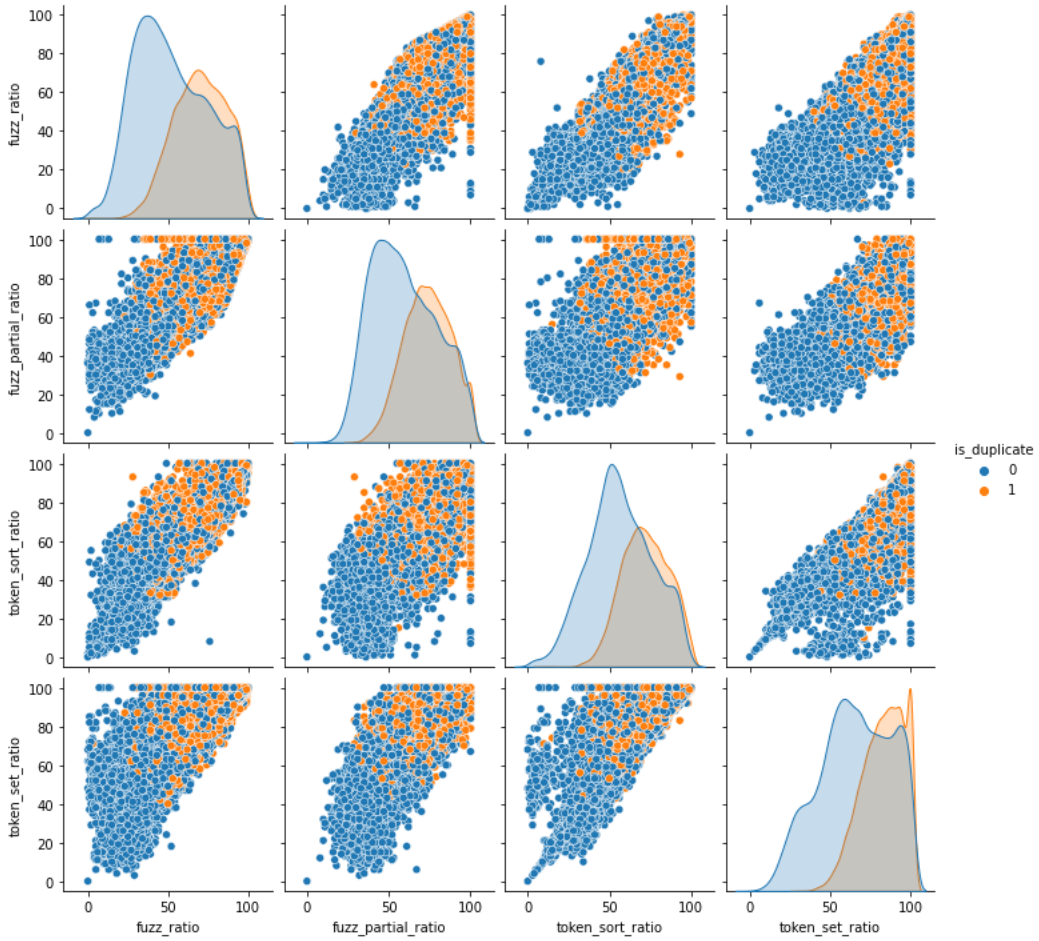
In [156]:
```
sns.pairplot(new_df[['mean_len', 'abs_len_diff','longest_substr_ratio', 'is_duplicate']],hue='is_duplicate')
```

Out[156]: <seaborn.axisgrid.PairGrid at 0x18708709d30>



In [157]:
```
sns.pairplot(new_df[['fuzz_ratio', 'fuzz_partial_ratio','token_sort_ratio','token_set_ratio', 'is_duplicate']],hue='is_dupli
```

Out[157]: <seaborn.axisgrid.PairGrid at 0x1870a1d2b80>



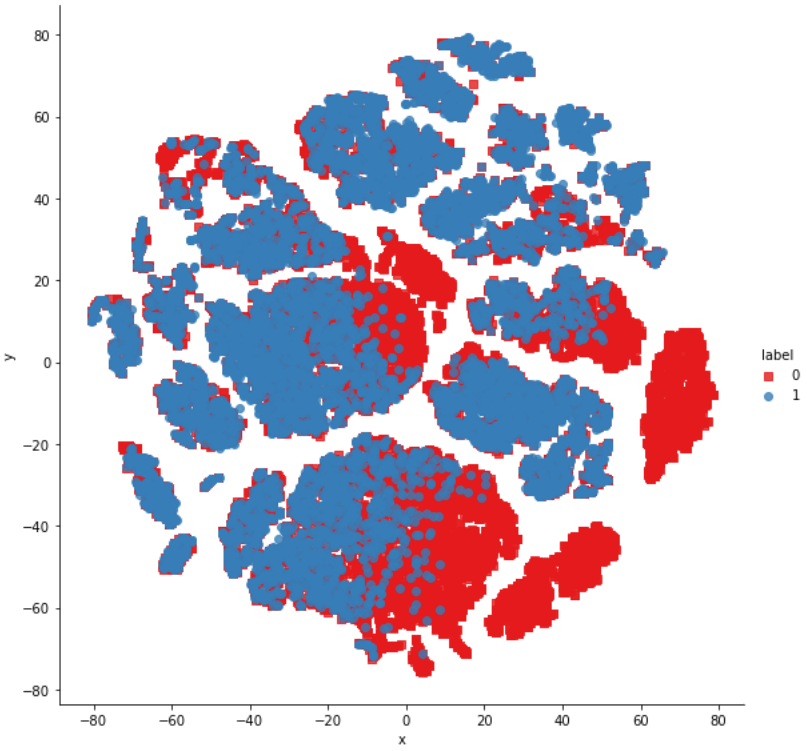
In [158]:
```
# Using TSNE for Dimentionality reduction for 15 Features(Generated after cleaning the data) to 3 dimention

from sklearn.preprocessing import MinMaxScaler

X = MinMaxScaler().fit_transform(new_df[['cwc_min', 'cwc_max', 'csc_min', 'csc_max' , 'ctc_min' , 'ctc_max' , 'last_word_eq'
y = new_df['is_duplicate'].values
```

In [159]:
```
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 30000 samples in 0.159s...
[t-SNE] Computed neighbors for 30000 samples in 6.390s...
[t-SNE] Computed conditional probabilities for sample 1000 / 30000
[t-SNE] Computed conditional probabilities for sample 2000 / 30000
[t-SNE] Computed conditional probabilities for sample 3000 / 30000
[t-SNE] Computed conditional probabilities for sample 4000 / 30000
[t-SNE] Computed conditional probabilities for sample 5000 / 30000
[t-SNE] Computed conditional probabilities for sample 6000 / 30000
[t-SNE] Computed conditional probabilities for sample 7000 / 30000
[t-SNE] Computed conditional probabilities for sample 8000 / 30000
[t-SNE] Computed conditional probabilities for sample 9000 / 30000
[t-SNE] Computed conditional probabilities for sample 10000 / 30000
[t-SNE] Computed conditional probabilities for sample 11000 / 30000
[t-SNE] Computed conditional probabilities for sample 12000 / 30000
[t-SNE] Computed conditional probabilities for sample 13000 / 30000
[t-SNE] Computed conditional probabilities for sample 14000 / 30000
[t-SNE] Computed conditional probabilities for sample 15000 / 30000
[t-SNE] Computed conditional probabilities for sample 16000 / 30000
[t-SNE] Computed conditional probabilities for sample 17000 / 30000
[t-SNE] Computed conditional probabilities for sample 18000 / 30000
[t-SNE] Computed conditional probabilities for sample 19000 / 30000
[t-SNE] Computed conditional probabilities for sample 20000 / 30000
[t-SNE] Computed conditional probabilities for sample 21000 / 30000
[t-SNE] Computed conditional probabilities for sample 22000 / 30000
[t-SNE] Computed conditional probabilities for sample 23000 / 30000
[t-SNE] Computed conditional probabilities for sample 24000 / 30000
[t-SNE] Computed conditional probabilities for sample 25000 / 30000
[t-SNE] Computed conditional probabilities for sample 26000 / 30000
[t-SNE] Computed conditional probabilities for sample 27000 / 30000
[t-SNE] Computed conditional probabilities for sample 28000 / 30000
[t-SNE] Computed conditional probabilities for sample 29000 / 30000
[t-SNE] Computed conditional probabilities for sample 30000 / 30000
[t-SNE] Mean sigma: 0.087420
[t-SNE] Computed conditional probabilities in 1.120s
[t-SNE] Iteration 50: error = 111.1139450, gradient norm = 0.0000528 (50 iterations in 9.618s)
[t-SNE] Iteration 100: error = 92.4731140, gradient norm = 0.0029080 (50 iterations in 10.295s)
[t-SNE] Iteration 150: error = 86.6217270, gradient norm = 0.0014014 (50 iterations in 8.987s)
[t-SNE] Iteration 200: error = 84.3923798, gradient norm = 0.0009428 (50 iterations in 9.675s)
[t-SNE] Iteration 250: error = 83.2190552, gradient norm = 0.0007072 (50 iterations in 9.664s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 83.219055
[t-SNE] Iteration 300: error = 3.8108232, gradient norm = 0.0011424 (50 iterations in 9.858s)
[t-SNE] Iteration 350: error = 3.2906470, gradient norm = 0.0006687 (50 iterations in 10.132s)
[t-SNE] Iteration 400: error = 2.9285789, gradient norm = 0.0004417 (50 iterations in 9.777s)
[t-SNE] Iteration 450: error = 2.6810791, gradient norm = 0.0003204 (50 iterations in 9.914s)
[t-SNE] Iteration 500: error = 2.5010517, gradient norm = 0.0002474 (50 iterations in 9.856s)
[t-SNE] Iteration 550: error = 2.3637815, gradient norm = 0.0001989 (50 iterations in 9.691s)
[t-SNE] Iteration 600: error = 2.2556167, gradient norm = 0.0001645 (50 iterations in 9.516s)
[t-SNE] Iteration 650: error = 2.1680160, gradient norm = 0.0001390 (50 iterations in 9.498s)
[t-SNE] Iteration 700: error = 2.0954065, gradient norm = 0.0001198 (50 iterations in 9.805s)
[t-SNE] Iteration 750: error = 2.0341637, gradient norm = 0.0001048 (50 iterations in 10.480s)
[t-SNE] Iteration 800: error = 1.9818006, gradient norm = 0.0000927 (50 iterations in 10.568s)
[t-SNE] Iteration 850: error = 1.9364457, gradient norm = 0.0000829 (50 iterations in 10.624s)
[t-SNE] Iteration 900: error = 1.8966687, gradient norm = 0.0000748 (50 iterations in 10.716s)
[t-SNE] Iteration 950: error = 1.8615599, gradient norm = 0.0000680 (50 iterations in 10.481s)
[t-SNE] Iteration 1000: error = 1.8303556, gradient norm = 0.0000622 (50 iterations in 10.986s)
[t-SNE] KL divergence after 1000 iterations: 1.830356
```

In [160]:
```
x_df = pd.DataFrame({'x':tsne2d[:,0], 'y':tsne2d[:,1] ,'label':y})

# draw the plot in appropriate place in the grid
sns.lmplot(data=x_df, x='x', y='y', hue='label', fit_reg=False, size=8,palette="Set1",markers=['s','o'])
```

Out[160]: <seaborn.axisgrid.FacetGrid at 0x1870bdb3dc0>

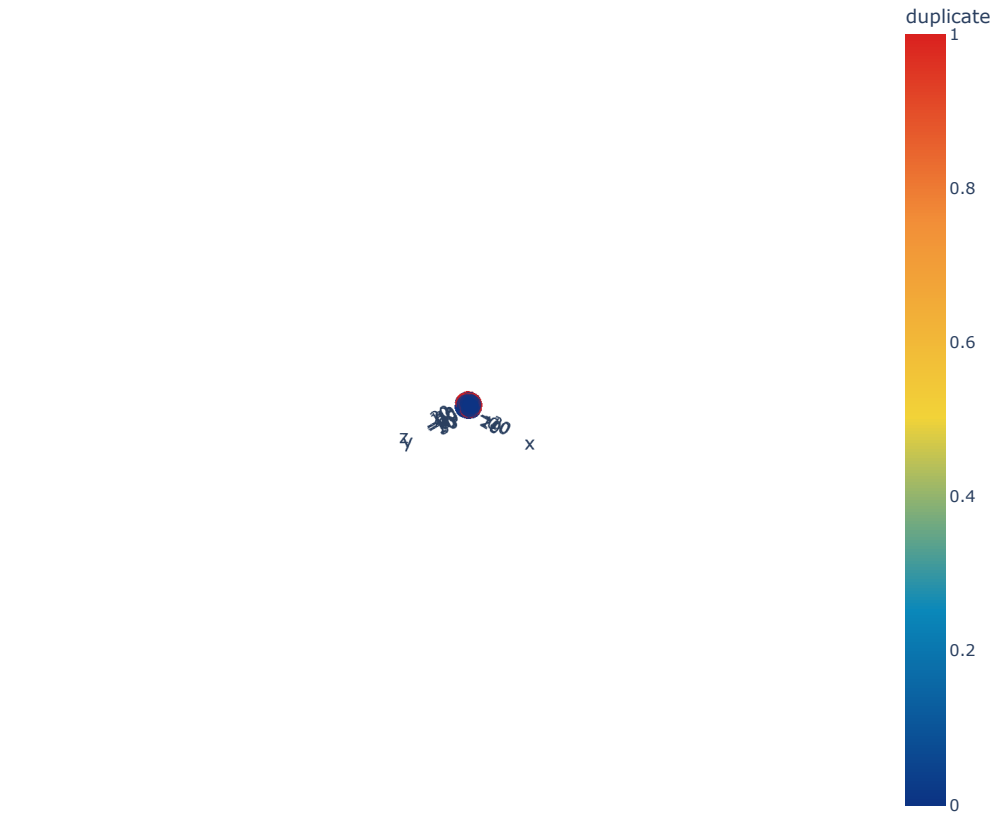


In [161]:
```
tsne3d = TSNE(
    n_components=3,
    init='random', # pca
    random_state=101,
    method='barnes_hut',
    n_iter=1000,
    verbose=2,
    angle=0.5
).fit_transform(X)
```

```
[t-SNE] Computing 91 nearest neighbors...
[t-SNE] Indexed 30000 samples in 0.170s...
[t-SNE] Computed neighbors for 30000 samples in 8.881s...
[t-SNE] Computed conditional probabilities for sample 1000 / 30000
[t-SNE] Computed conditional probabilities for sample 2000 / 30000
[t-SNE] Computed conditional probabilities for sample 3000 / 30000
[t-SNE] Computed conditional probabilities for sample 4000 / 30000
[t-SNE] Computed conditional probabilities for sample 5000 / 30000
[t-SNE] Computed conditional probabilities for sample 6000 / 30000
[t-SNE] Computed conditional probabilities for sample 7000 / 30000
[t-SNE] Computed conditional probabilities for sample 8000 / 30000
[t-SNE] Computed conditional probabilities for sample 9000 / 30000
[t-SNE] Computed conditional probabilities for sample 10000 / 30000
[t-SNE] Computed conditional probabilities for sample 11000 / 30000
[t-SNE] Computed conditional probabilities for sample 12000 / 30000
[t-SNE] Computed conditional probabilities for sample 13000 / 30000
[t-SNE] Computed conditional probabilities for sample 14000 / 30000
[t-SNE] Computed conditional probabilities for sample 15000 / 30000
[t-SNE] Computed conditional probabilities for sample 16000 / 30000
[t-SNE] Computed conditional probabilities for sample 17000 / 30000
[t-SNE] Computed conditional probabilities for sample 18000 / 30000
[t-SNE] Computed conditional probabilities for sample 19000 / 30000
[t-SNE] Computed conditional probabilities for sample 20000 / 30000
[t-SNE] Computed conditional probabilities for sample 21000 / 30000
[t-SNE] Computed conditional probabilities for sample 22000 / 30000
[t-SNE] Computed conditional probabilities for sample 23000 / 30000
[t-SNE] Computed conditional probabilities for sample 24000 / 30000
[t-SNE] Computed conditional probabilities for sample 25000 / 30000
[t-SNE] Computed conditional probabilities for sample 26000 / 30000
[t-SNE] Computed conditional probabilities for sample 27000 / 30000
[t-SNE] Computed conditional probabilities for sample 28000 / 30000
[t-SNE] Computed conditional probabilities for sample 29000 / 30000
[t-SNE] Computed conditional probabilities for sample 30000 / 30000
[t-SNE] Mean sigma: 0.087420
[t-SNE] Computed conditional probabilities in 1.157s
[t-SNE] Iteration 50: error = 111.1141052, gradient norm = 0.0000095 (50 iterations in 20.843s)
[t-SNE] Iteration 100: error = 92.1124878, gradient norm = 0.0019646 (50 iterations in 24.411s)
[t-SNE] Iteration 150: error = 85.0801544, gradient norm = 0.0007227 (50 iterations in 21.225s)
[t-SNE] Iteration 200: error = 83.1425705, gradient norm = 0.0004393 (50 iterations in 19.145s)
[t-SNE] Iteration 250: error = 82.1798553, gradient norm = 0.0002817 (50 iterations in 19.086s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 82.179855
[t-SNE] Iteration 300: error = 3.4739718, gradient norm = 0.0008218 (50 iterations in 21.519s)
[t-SNE] Iteration 350: error = 2.8796194, gradient norm = 0.0003712 (50 iterations in 25.331s)
[t-SNE] Iteration 400: error = 2.5150728, gradient norm = 0.0002101 (50 iterations in 24.924s)
[t-SNE] Iteration 450: error = 2.2753220, gradient norm = 0.0001347 (50 iterations in 26.005s)
[t-SNE] Iteration 500: error = 2.1078000, gradient norm = 0.0000941 (50 iterations in 24.315s)
[t-SNE] Iteration 550: error = 1.9846343, gradient norm = 0.0000698 (50 iterations in 25.387s)
[t-SNE] Iteration 600: error = 1.8901992, gradient norm = 0.0000538 (50 iterations in 26.536s)
[t-SNE] Iteration 650: error = 1.8153672, gradient norm = 0.0000431 (50 iterations in 25.098s)
[t-SNE] Iteration 700: error = 1.7544904, gradient norm = 0.0000353 (50 iterations in 26.003s)
[t-SNE] Iteration 750: error = 1.7041844, gradient norm = 0.0000294 (50 iterations in 26.094s)
[t-SNE] Iteration 800: error = 1.6622106, gradient norm = 0.0000257 (50 iterations in 24.552s)
[t-SNE] Iteration 850: error = 1.6266277, gradient norm = 0.0000225 (50 iterations in 25.561s)
[t-SNE] Iteration 900: error = 1.5962178, gradient norm = 0.0000198 (50 iterations in 24.661s)
[t-SNE] Iteration 950: error = 1.5701591, gradient norm = 0.0000179 (50 iterations in 24.392s)
[t-SNE] Iteration 1000: error = 1.5478457, gradient norm = 0.0000165 (50 iterations in 27.312s)
[t-SNE] KL divergence after 1000 iterations: 1.547846
```

In [162]:

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

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')
```



In [163]:
```
ques_df = new_df[['question1','question2']]
ques_df.head()
```

Out[163]:

	question1	question2
237030	how can i stop playing video games	should i stop playing video games with my child
247341	who is better donald trump or hillary clinton	why is hillary clinton a better choice than do...
246425	what do you think is the chance that sometime ...	do you think there will be another world war n...
306985	why are so many questions posted to quora that...	why do people write questions on quora that co...
225863	can there even be a movie ever rated 10 10 on ...	what are your 10 10 movies

In [164]:
```
final_df = new_df.drop(columns=['id','qid1','qid2','question1','question2'])
print(final_df.shape)
final_df.head()
```

```
(30000, 23)
```

Out[164]:

	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total	word_share	cwc_min	cwc_max	...	ctc_max	last_word_eq
237030	0	34	47	7	9	5	16	0.31	0.999975	0.799984	...	0.555549	0.0
247341	1	45	56	8	10	6	18	0.33	0.999980	0.833319	...	0.599994	0.0
246425	1	137	76	29	15	13	40	0.32	0.857131	0.499996	...	0.464284	0.0
306985	1	85	85	16	16	5	30	0.17	0.374995	0.333330	...	0.312498	0.0
225863	0	50	26	12	6	1	16	0.06	0.499975	0.166664	...	0.083333	0.0

5 rows × 23 columns

In [165]:
```
from sklearn.feature_extraction.text import CountVectorizer
# merge texts
questions = list(ques_df['question1']) + list(ques_df['question2'])

cv = CountVectorizer(max_features=3000)
q1_arr, q2_arr = np.vsplit(cv.fit_transform(questions).toarray(),2)
```

In [166]:
```
temp_df1 = pd.DataFrame(q1_arr, index= ques_df.index)
temp_df2 = pd.DataFrame(q2_arr, index= ques_df.index)
temp_df = pd.concat([temp_df1, temp_df2], axis=1)
temp_df.shape
```

Out[166]: (30000, 6000)

In [167]:
```
final_df = pd.concat([final_df, temp_df], axis=1)
print(final_df.shape)
final_df.head()
```

```
(30000, 6023)
```

Out[167]:

	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_total	word_share	cwc_min	cwc_max	...	2990	2991	2992	2993
237030	0	34	47	7	9	5	16	0.31	0.999975	0.799984	...	0	0	0	0
247341	1	45	56	8	10	6	18	0.33	0.999980	0.833319	...	0	0	0	0
246425	1	137	76	29	15	13	40	0.32	0.857131	0.499996	...	0	1	0	0
306985	1	85	85	16	16	5	30	0.17	0.374995	0.333330	...	0	0	0	0
225863	0	50	26	12	6	1	16	0.06	0.499975	0.166664	...	0	0	0	0

5 rows × 6023 columns

In [168]:
```
om sklearn.model_selection import train_test_split
train,X_test,y_train,y_test = train_test_split(final_df.iloc[:,1:].values,final_df.iloc[:,0].values,test_size=0.2,random_state=1)
```

In [169]:
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
rf = RandomForestClassifier()
rf.fit(X_train,y_train)
y_pred = rf.predict(X_test)
accuracy_score(y_test,y_pred)
```

Out[169]: 0.785

In [218]:
```
# rf = RandomForestClassifier()
# rf.fit(X_train,y_train)
y_pred = rf.predict(X_test)
accuracy_score(y_train[:6000],y_pred)
```

Out[218]: 0.5371666666666667

In [ ]:
```

```

In [212]:
```
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           0       0.82      0.85      0.83      3810
           1       0.72      0.68      0.70      2190

    accuracy                           0.79      6000
   macro avg       0.77      0.76      0.77      6000
weighted avg       0.78      0.79      0.78      6000
```

In [170]:
```
from xgboost import XGBClassifier
xgb = XGBClassifier()
xgb.fit(X_train,y_train)
y_pred1 = xgb.predict(X_test)
accuracy_score(y_test,y_pred1)
```

Out[170]: 0.785

In [211]:
```
print(classification_report(y_test, y_pred1))
```

```
              precision    recall  f1-score   support

           0       0.83      0.83      0.83      3810
           1       0.70      0.71      0.71      2190

    accuracy                           0.79      6000
   macro avg       0.77      0.77      0.77      6000
weighted avg       0.79      0.79      0.79      6000
```

In [171]:
```
from lightgbm import LGBMClassifier
lgb = LGBMClassifier()
lgb.fit(X_train,y_train)
y_pred2 = lgb.predict(X_test)
accuracy_score(y_test,y_pred2)
```

Out[171]: 0.7911666666666667

In [210]:
```
print(classification_report(y_test, y_pred2))
```

```
              precision    recall  f1-score   support

           0       0.84      0.84      0.84      3810
           1       0.71      0.71      0.71      2190

    accuracy                           0.79      6000
   macro avg       0.77      0.77      0.77      6000
weighted avg       0.79      0.79      0.79      6000
```

In [172]:
```
from sklearn.metrics import confusion_matrix
```

In [173]:
```
# for random forest model
confusion_matrix(y_test,y_pred)
```

Out[173]:
```
array([[3224,  586],
       [ 704, 1486]], dtype=int64)
```

In [174]:
```
# for xgboost model
confusion_matrix(y_test,y_pred1)
```

Out[174]:
```
array([[3162,  648],
       [ 642, 1548]], dtype=int64)
```

In [176]:
```
# for lightgbm model
confusion_matrix(y_test,y_pred2)
```

Out[176]:
```
array([[3182,  628],
       [ 625, 1565]], dtype=int64)
```

We will choose the random forest model because in our case we should consider low False positive like it was actual not duplicate question but our model predicted as duplicate. so it will make a bad user experience !

In [ ]:
```
1
```

In [181]:
```
def test_common_words(q1,q2):
    w1 = set(map(lambda word: word.lower().strip(), q1.split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), q2.split(" ")))
    return len(w1 & w2)
```

In [182]:
```
def test_total_words(q1,q2):
    w1 = set(map(lambda word: word.lower().strip(), q1.split(" ")))
    w2 = set(map(lambda word: word.lower().strip(), q2.split(" ")))
    return (len(w1) + len(w2))
```

In [183]:
```
def test_fetch_token_features(q1,q2):

    SAFE_DIV = 0.0001

    STOP_WORDS = stopwords.words("english")

    token_features = [0.0]*8

    # 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)

    # 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])

    return token_features
```

In [184]:
```python
def test_fetch_length_features(q1,q2):

    length_features = [0.0]*3

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

    if len(q1_tokens) == 0 or len(q2_tokens) == 0:
        return length_features

    # Absolute length features
    length_features[0] = abs(len(q1_tokens) - len(q2_tokens))

    #Average Token Length of both Questions
    length_features[1] = (len(q1_tokens) + len(q2_tokens))/2

    strs = list(distance.lcsubstrings(q1, q2))
    length_features[2] = len(strs[0]) / (min(len(q1), len(q2)) + 1)

    return length_features
```

In [185]:
```python
def test_fetch_fuzzy_features(q1,q2):

    fuzzy_features = [0.0]*4

    # fuzz_ratio
    fuzzy_features[0] = fuzz.QRatio(q1, q2)

    # fuzz_partial_ratio
    fuzzy_features[1] = fuzz.partial_ratio(q1, q2)

    # token_sort_ratio
    fuzzy_features[2] = fuzz.token_sort_ratio(q1, q2)

    # token_set_ratio
    fuzzy_features[3] = fuzz.token_set_ratio(q1, q2)

    return fuzzy_features
```

In [186]:
```python
def query_point_creator(q1,q2):

    input_query = []

    # preprocess
    q1 = preprocess(q1)
    q2 = preprocess(q2)

    # fetch basic features
    input_query.append(len(q1))
    input_query.append(len(q2))

    input_query.append(len(q1.split(" ")))
    input_query.append(len(q2.split(" ")))

    input_query.append(test_common_words(q1,q2))
    input_query.append(test_total_words(q1,q2))
    input_query.append(round(test_common_words(q1,q2)/test_total_words(q1,q2),2))

    # fetch token features
    token_features = test_fetch_token_features(q1,q2)
    input_query.extend(token_features)

    # fetch length based features
    length_features = test_fetch_length_features(q1,q2)
    input_query.extend(length_features)

    # fetch fuzzy features
    fuzzy_features = test_fetch_fuzzy_features(q1,q2)
    input_query.extend(fuzzy_features)

    # bow feature for q1
    q1_bow = cv.transform([q1]).toarray()

    # bow feature for q2
    q2_bow = cv.transform([q2]).toarray()



    return np.hstack((np.array(input_query).reshape(1,22),q1_bow,q2_bow))
```

In [187]:
```
q1 = 'Where is the capital of India?'
q2 = 'What is the current capital of Pakistan?'
q3 = 'Which city serves as the capital of India?'
q4 = 'What is the business capital of India?'
```

In [188]:
```
rf.predict(query_point_creator(q1,q4))

```

Out[188]:
```
array([1], dtype=int64)
```

In [189]:
```
cv
```

Out[189]:
```
CountVectorizer(max_features=3000)
```

In [191]:
```
import pickle

pickle.dump(rf,open('quora_duplicate_question_model.pkl','wb'))
pickle.dump(cv,open('cv.pkl','wb'))
```

deployement

In [205]:
```
# !pip install streamlit
# !pip install helper
# !pip install grp
# !pip uninstall celery
# !pip install celery==5.0.5
```

In [207]:
```
# import streamlit as st
# import helper

# import pickle

# model = pickle.load(open('model.pkl','rb'))

# st.header('Duplicate Question Pairs')

# q1 = st.text_input('Enter question 1')
# q2 = st.text_input('Enter question 2')

# if st.button('Find'):
#     query = helper.query_point_creator(q1,q2)
#     result = model.predict(query)[0]

#     if result:
#         st.header('Duplicate')
#     else:
#         st.header('Not Duplicate')
```

In [ ]:
```
q1
```

In [3]:
```
# pip install nbconvert
```

In [7]:
```
# !pip install sudo apt-get install pandoc
```

In [ ]:
```

```