1.Quora

February 27, 2019

Quora Question Pairs

1. Business Problem

1.1 Description

Quora is a place to gain and share knowledge—about anything. It's a platform to ask questions and connect with people who contribute unique insights and quality answers. This empowers people to learn from each other and to better understand the world.

Over 100 million people visit Quora every month, so it's no surprise that many people ask similarly worded questions. Multiple questions with the same intent can cause seekers to spend more time finding the best answer to their question, and make writers feel they need to answer multiple versions of the same question. Quora values canonical questions because they provide a better experience to active seekers and writers, and offer more value to both of these groups in the long term.

> Credits: Kaggle

__ Problem Statement __ - Identify which questions asked on Quora are duplicates of questions that have already been asked. - This could be useful to instantly provide answers to questions that have already been answered. - We are tasked with predicting whether a pair of questions are duplicates or not.

1.2 Sources/Useful Links

- Source : https://www.kaggle.com/c/quora-question-pairs ____ Useful Links ____
- Discussions : https://www.kaggle.com/anokas/data-analysis-xgboost-starter-0-35460-lb/comments
- Kaggle Winning Solution and other approaches: https://www.dropbox.com/sh/93968nfnrzh8bp5/AACZd
- Blog 1 : https://engineering.quora.com/Semantic-Question-Matching-with-Deep-Learning
- Blog 2 : https://towardsdatascience.com/identifying-duplicate-questions-on-quora-top-12-on-kaggle-4c1cf93f1c30

1.3 Real world/Business Objectives and Constraints

1. The cost of a mis-classification can be very high.
2. You would want a probability of a pair of questions to be duplicates so that you can choose any threshold of choice.
3. No strict latency concerns.
4. Interpretability is partially important.

2. Machine Learning Probelm

2.1 Data

2.1.1 Data Overview

- Data will be in a file Train.csv
- Train.csv contains 5 columns : qid1, qid2, question1, question2, is_duplicate
- Size of Train.csv - 60MB
- Number of rows in Train.csv = 404,290

2.1.2 Example Data point

2.2 Mapping the real world problem to an ML problem

2.2.1 Type of Machine Leaning Problem

It is a binary classification problem, for a given pair of questions we need to predict if they are duplicate or not.

2.2.2 Performance Metric

Source: https://www.kaggle.com/c/quora-question-pairs#evaluation

Metric(s): * log-loss : https://www.kaggle.com/wiki/LogarithmicLoss * Binary Confusion Matrix

2.3 Train and Test Construction

We build train and test by randomly splitting in the ratio of 70:30 or 80:20 whatever we choose as we have sufficient points to work with.

3. Exploratory Data Analysis

```
In [7]: import numpy as np
        import pandas as pd
        import seaborn as sns
        import matplotlib.pyplot as plt
        from subprocess import check_output
        %matplotlib inline
        import plotly.offline as py
        py.init_notebook_mode(connected=True)
        import plotly.graph_objs as go
        import plotly.tools as tls
        import os
        import gc

        import re
        from nltk.corpus import stopwords
        import distance
        from nltk.stem import PorterStemmer
        from bs4 import BeautifulSoup
```

3.1 Reading data and basic stats

```
In [8]: df = pd.read_csv("train.csv")

        print("Number of data points:",df.shape[0])
```

```
Number of data points: 404290
```

```
In [9]: df.head()
```

```
Out[9]:    id  qid1  qid2                                                question1  \
        0   0     1     2  What is the step by step guide to invest in sh...
        1   1     3     4  What is the story of Kohinoor (Koh-i-Noor) Dia...
        2   2     5     6  How can I increase the speed of my internet co...
        3   3     7     8  Why am I mentally very lonely? How can I solve...
        4   4     9    10  Which one dissolve in water quikly sugar, salt...

                                                   question2  is_duplicate
        0  What is the step by step guide to invest in sh...             0
        1  What would happen if the Indian government sto...             0
        2  How can Internet speed be increased by hacking...             0
        3  Find the remainder when [math]23^{24}[/math] i...             0
        4            Which fish would survive in salt water?             0
```

```
In [10]: 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
```

We are given a minimal number of data fields here, consisting of:

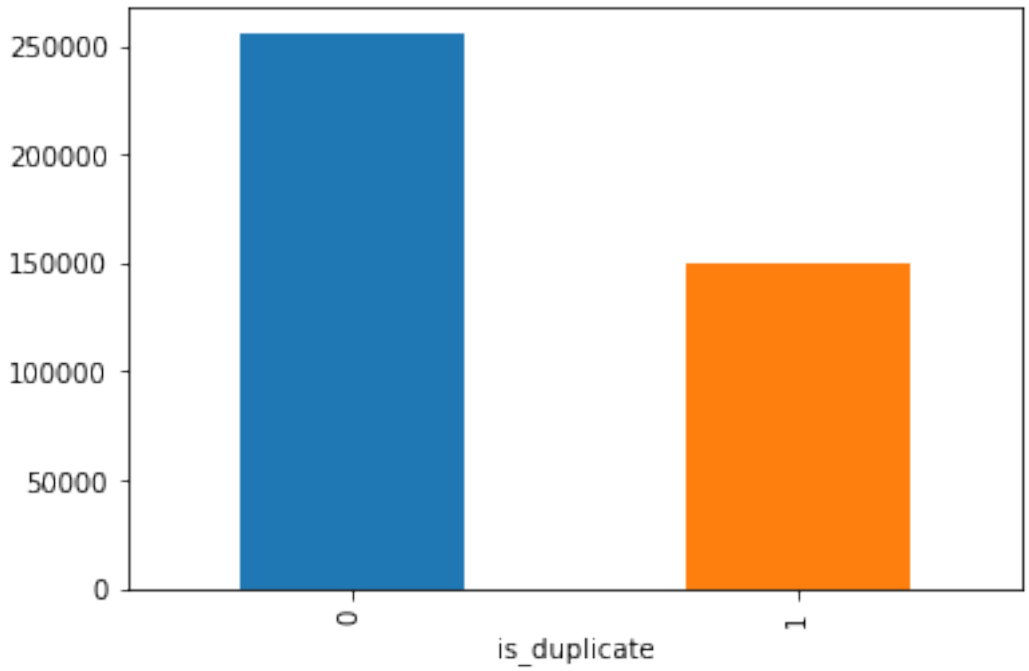
- id: Looks like a simple rowID
- qid{1, 2}: The unique ID of each question in the pair
- question{1, 2}: The actual textual contents of the questions.
- is_duplicate: The label that we are trying to predict - whether the two questions are duplicates of each other.

3.2.1 Distribution of data points among output classes

- Number of duplicate(smilar) and non-duplicate(non similar) questions

```
In [11]: df.groupby("is_duplicate")['id'].count().plot.bar()
```

```
Out[11]: <matplotlib.axes._subplots.AxesSubplot at 0x29855af4f60>
```




```
In [12]: print('~> Total number of question pairs for training:\n   {}'.format(len(df)))
```

```
~> Total number of question pairs for training:
   404290
```

```
In [13]: print('~> Question pairs are not Similar (is_duplicate = 0):\n   {}%'.format(100 - rou
         print('\n~> Question pairs are Similar (is_duplicate = 1):\n   {}%'.format(round(df['
```

```
~> Question pairs are not Similar (is_duplicate = 0):
   63.08%

~> Question pairs are Similar (is_duplicate = 1):
   36.92%
```

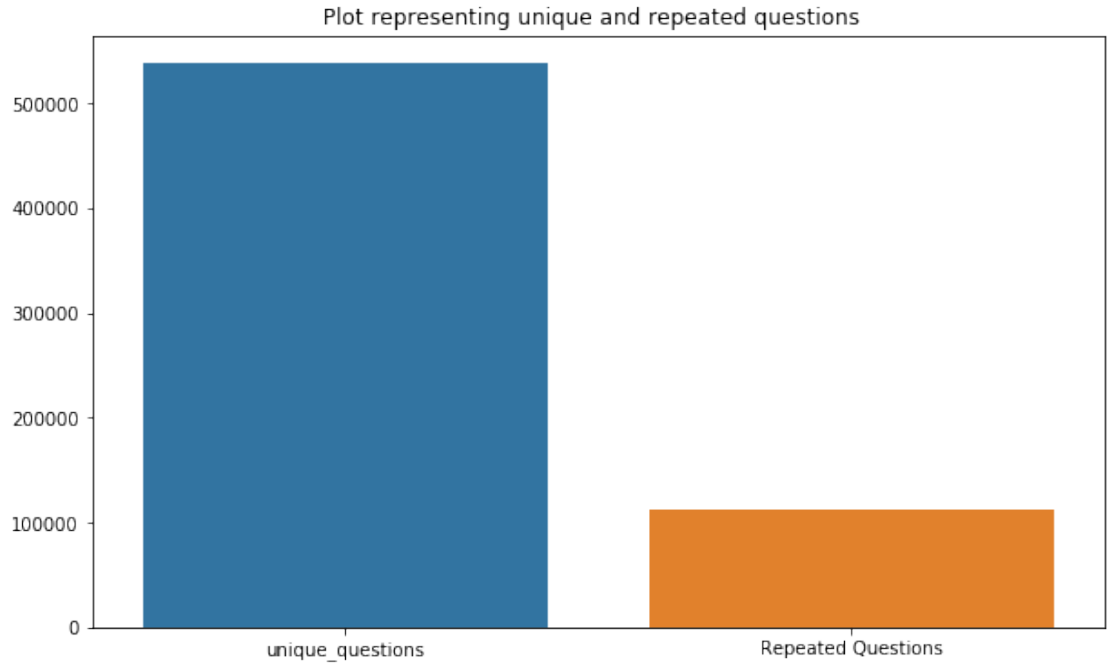
3.2.2 Number of unique questions

```
In [14]: qids = pd.Series(df['qid1'].tolist() + df['qid2'].tolist())
         unique_qs = len(np.unique(qids))
         qs_morethan_onetime = np.sum(qids.value_counts() > 1)
         print ('Total number of  Unique Questions are: {}\n'.format(unique_qs))
         #print len(np.unique(qids))

         print ('Number of unique questions that appear more than one time: {} ({}%)\n'.format
```

```
        print ('Max number of times a single question is repeated: {}\n'.format(max(qids.value

        q_vals=qids.value_counts()

        q_vals=q_vals.values
```

```
Total number of  Unique Questions are: 537933

Number of unique questions that appear more than one time: 111780 (20.77953945937505%)

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

```
In [15]: x = ["unique_questions" , "Repeated Questions"]
         y =  [unique_qs , qs_morethan_onetime]

         plt.figure(figsize=(10, 6))
         plt.title ("Plot representing unique and repeated questions  ")
         sns.barplot(x,y)
         plt.show()
```



3.2.3 Checking for Duplicates

```
In [16]: #checking whether there are any repeated pair of questions
```

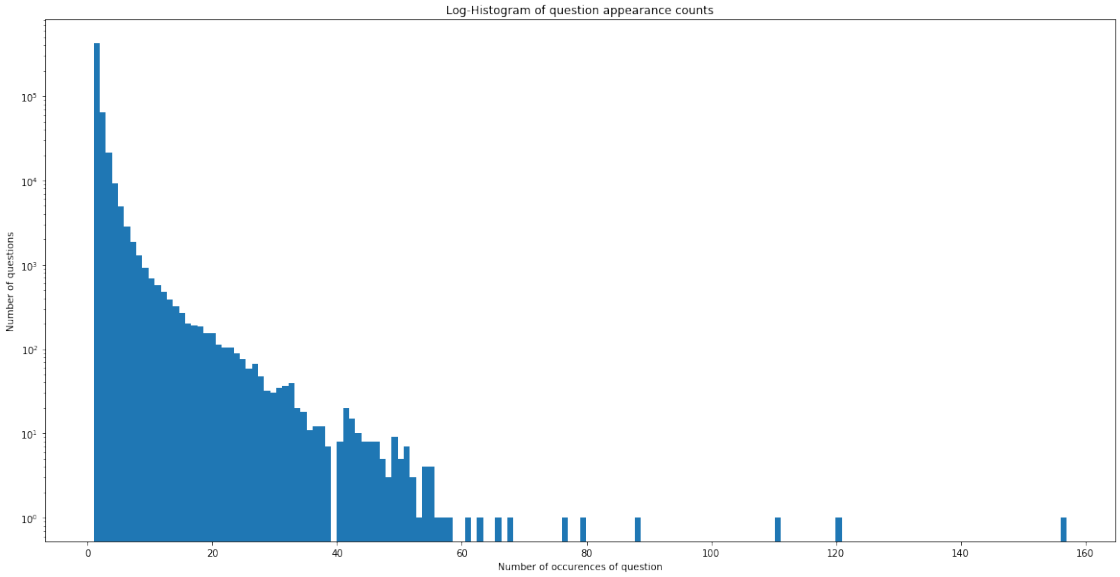
```
        pair_duplicates = df[['qid1','qid2','is_duplicate']].groupby(['qid1','qid2']).count()

        print ("Number of duplicate questions",(pair_duplicates).shape[0] - df.shape[0])
```

```
Number of duplicate questions 0
```

3.2.4 Number of occurrences of each question

```
In [17]: plt.figure(figsize=(20, 10))

         plt.hist(qids.value_counts(), bins=160)

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

         plt.title('Log-Histogram of question appearance counts')

         plt.xlabel('Number of occurences of question')

         plt.ylabel('Number of questions')

         print ('Maximum number of times a single question is repeated: {}\n'.format(max(qids.
```

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



3.2.5 Checking for NULL values

```
In [18]: #Checking whether there are any rows with 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
```

- There are two rows with null values in question2

```
In [19]: # Filling the null values with ' '
         df = df.fillna('')
         nan_rows = df[df.isnull().any(1)]
         print (nan_rows)
```

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

3.3 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 [20]: if os.path.isfile('df_fe_without_preprocessing_train.csv'):
             df = pd.read_csv("df_fe_without_preprocessing_train.csv",encoding='latin-1')
         else:
             df['freq_qid1'] = df.groupby('qid1')['qid1'].transform('count')
             df['freq_qid2'] = df.groupby('qid2')['qid2'].transform('count')
             df['q1len'] = df['question1'].str.len()
             df['q2len'] = df['question2'].str.len()
             df['q1_n_words'] = df['question1'].apply(lambda row: len(row.split(" ")))
             df['q2_n_words'] = df['question2'].apply(lambda row: len(row.split(" ")))

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

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

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

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

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

df.head()
```

Out[20]:

	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+q2	freq_q1-q2
0	0	1	2	What is the step by step guide to invest in sh...	What is the step by step guide to invest in sh...	0	1	1	66	57	14	12	10.0	23.0	0.434783	2	0
1	1	3	4	What is the story of Kohinoor (Koh-i-Noor) Dia...	What would happen if the Indian government sto...	0	4	1	51	88	8	13	4.0	20.0	0.200000	5	3
2	2	5	6	How can I increase the speed of my internet co...	How can Internet speed be increased by hacking...	0	1	1	73	59	14	10	4.0	24.0	0.166667	2	0
3	3	7	8	Why am I mentally very lonely? How can I solve...	Find the remainder when [math]23^{24}[/math] i...	0	1	1	50	65	11	9	0.0	19.0	0.000000	2	0
4	4	9	10	Which one dissolve in water quikly sugar, salt...	Which fish would survive in salt water?	0	3	1	76	39	13	7	2.0	20.0	0.100000	4	2

3.3.1 Analysis of some of the extracted features

- Here are some questions have only one single words.

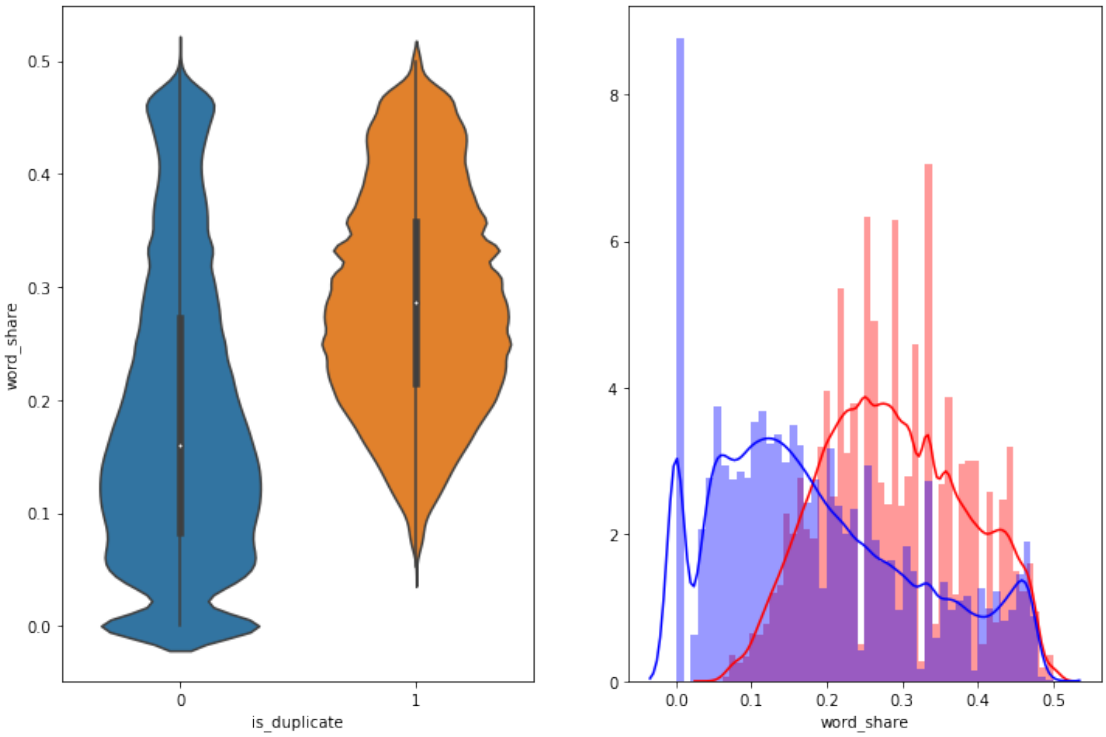
```
In [21]: print ("Minimum length of the questions in question1 : " , min(df['q1_n_words']))

         print ("Minimum length of the questions in question2 : " , min(df['q2_n_words']))

         print ("Number of Questions with minimum length [question1] :", df[df['q1_n_words']==
         print ("Number of Questions with minimum length [question2] :", df[df['q2_n_words']==
```

```
Minimum length of the questions in question1 :  1
Minimum length of the questions in question2 :  1
Number of Questions with minimum length [question1] : 67
Number of Questions with minimum length [question2] : 24
```

3.3.1.1 Feature: word_share

```
In [22]: plt.figure(figsize=(12, 8))

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

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

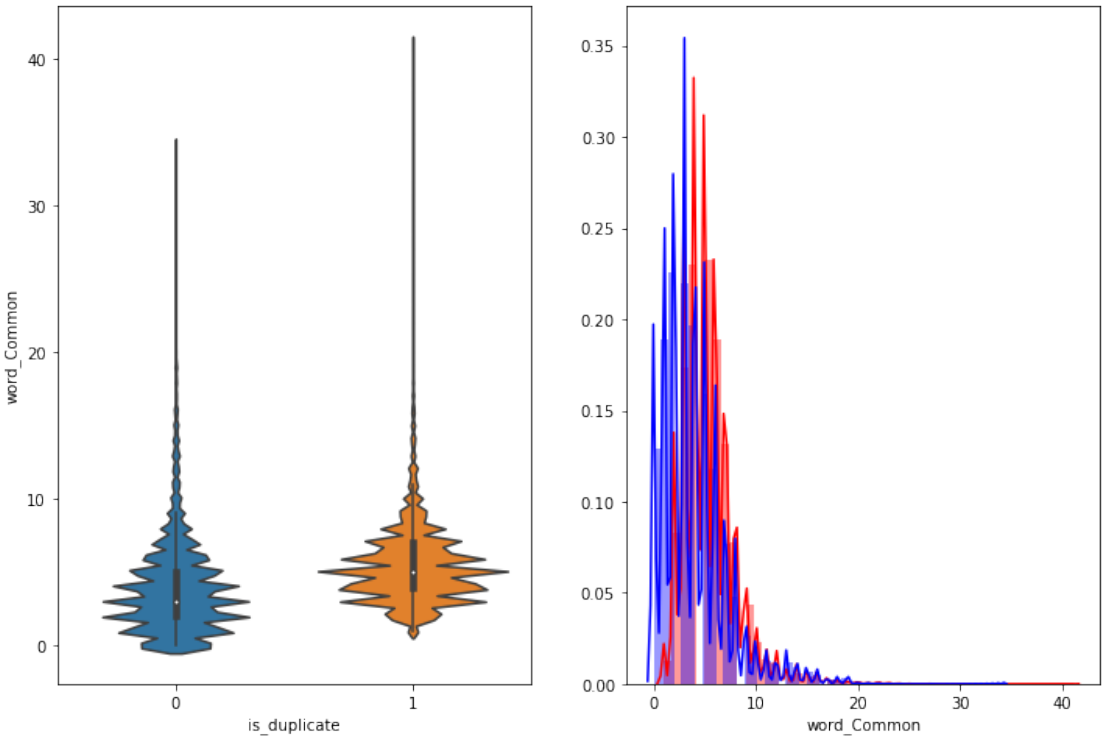
```
c:\users\dell\appdata\local\programs\python\python36\lib\site-packages\scipy\stats\stats.py:17

Using a non-tuple sequence for multidimensional indexing is deprecated; use `arr[tuple(seq)]` i
```



- The distributions for normalized word_share have some overlap on the far right-hand side, i.e., there are quite a lot of questions with high word similarity
- The average word share and Common no. of words of qid1 and qid2 is more when they are duplicate(Similar)

3.3.1.2 Feature: word_Common

```
In [23]: plt.figure(figsize=(12, 8))

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

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



The distributions of the word_Common feature in similar and non-similar questions are highly overlapping