1.2.1 : EDA: Advanced Feature Extraction.

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

```
Go to this URL in a browser: https://accounts.google.com/o/oauth2/auth?client_id=947318989803-6bn6qk8qdgf4n4g3pfee6491h

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

```
pip install distance
```

```
Collecting distance
  Downloading https://files.pythonhosted.org/packages/5c/1a/883e47df323437aefa0d0a92ccfb38895d9416bd0b56262c2e46a47767b
     |████████████████████████████████| 184kB 2.7MB/s
Building wheels for collected packages: distance
  Building wheel for distance (setup.py) ... done
  Created wheel for distance: filename=Distance-0.1.3-cp36-none-any.whl size=16261 sha256=cd59b76f3808b3411cb61ca5cb39d
  Stored in directory: /root/.cache/pip/wheels/d5/aa/e1/dbba9e7b6d397d645d0f12db1c66dbae9c5442b39b001db18e
Successfully built distance
Installing collected packages: distance
Successfully installed distance-0.1.3
```

```
pip install fuzzywuzzy
```

```
Collecting fuzzywuzzy
  Downloading https://files.pythonhosted.org/packages/d8/f1/5a267addb30ab7eaa1beab2b9323073815da4551076554ecc890a3595ec
Installing collected packages: fuzzywuzzy
Successfully installed fuzzywuzzy-0.17.0
```

```
import warnings
warnings.filterwarnings("ignore")
import numpy as np
```

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

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

```
#https://stackoverflow.com/questions/12468179/unicodedecodeerror-utf8-codec-cant-decode-byte-0x9c
if os.path.isfile('/content/drive/My Drive/qqps/df_fe_without_preprocessing_train.csv'):
    df = pd.read_csv("/content/drive/My Drive/qqps/df_fe_without_preprocessing_train.csv",encoding='latin-1')
    df = df.fillna('')
    df.head()
```

```
    df.head()
else:
    print("get df_fe_without_preprocessing_train.csv from drive or run the previous notebook")

df.head(2)
```

	id	qid1	qid2	question1	question2	is_duplicate	freq_qid1	freq_qid2	q1len	q2len	q1_n_words	q2_n_words	word
0	0	1	2	What is the step by step guide to invest in sh...	What is the step by step guide to invest in sh...	0	1	1	66	57	14	12	
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	

3.4 Preprocessing of Text

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

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

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
True
```

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

STOP_WORDS = stopwords.words("english")


def preprocess(x):
    x = str(x).lower()
    x = x.replace(",000,000", "m").replace(",000", "k").replace("’", "'").replace("’", "'")\
                           .replace("won't", "will not").replace("cannot", "can not").replace("can't", "can not")\
                           .replace("n't", " not").replace("what's", "what is").replace("it's", "it is")\
                           .replace("'ve", " have").replace("i'm", "i am").replace("'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)


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

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


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


    return x
```

- Function to Compute and get the features : With 2 parameters of Question 1 and Question 2

3.5 Advanced Feature Extraction (NLP and Fuzzy Features)

Definition:

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

Features:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- **longest_substr_ratio** : Ratio of length longest common substring to min lenghth of token count of Q1 and Q2

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

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

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

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

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

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

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


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

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

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

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

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

    # get the Longest Common sub string

    def get_longest_substr_ratio(a, b):
        strs = list(distance.lcsubstrings(a, b))
        if len(strs) == 0:
            return 0
        else:
            return len(strs[0]) / (min(len(a), len(b)) + 1)
```

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

    print("token features...")

    # Merging Features with dataset

    token_features = df.apply(lambda x: get_token_features(x["question1"], x["question2"]), axis=1)

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

    #Computing Fuzzy Features and Merging with Dataset

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

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


if os.path.isfile('/content/drive/My Drive/qqps/nlp_features_train.csv'):
```

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

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

	id	qid1	qid2	question1	question2	is_duplicate	cwc_min	cwc_max	csc_min	csc_max	ctc_min	ctc_max	last_wo
0	0	1	2	what is the step by step guide to invest in sh...	what is the step by step guide to invest in sh...	0	0.999980	0.833319	0.999983	0.999983	0.916659	0.785709	
1	1	3	4	what is the story of kohinoor koh i noor dia...	what would happen if the indian government sto...	0	0.799984	0.399996	0.749981	0.599988	0.699993	0.466664	

3.5.1 Analysis of extracted features

3.5.1.1 Plotting Word clouds

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

```
df_duplicate = df[df['is_duplicate'] == 1]
dfp_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([dfp_nonduplicate["question1"], dfp_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('/content/drive/My Drive/qqps/train_p.txt', p, delimiter=' ', fmt='%s', encoding='utf8')
np.savetxt('/content/drive/My Drive/qqps/train_n.txt', n, delimiter=' ', fmt='%s', encoding='utf8')
```

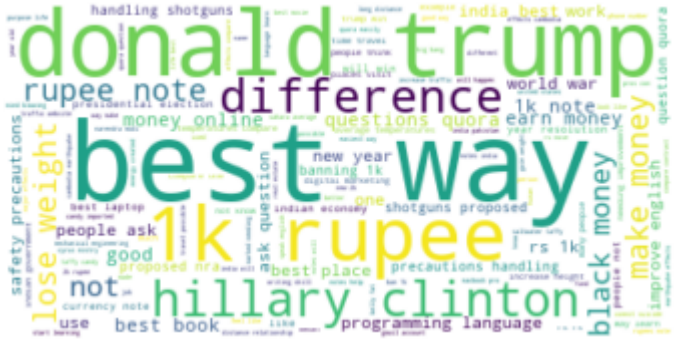
```
Number of data points in class 1 (duplicate pairs) : 298526
Number of data points in class 0 (non duplicate pairs) : 510054
```

```
# reading the text files and removing the Stop Words:
d = path.dirname('.')

import io
textp_w = io.open(path.join(d, 'train_p.txt'),encoding="utf-8").read()
textn_w = io.open(path.join(d, 'train_n.txt'),encoding="utf-8").read()
stopwords = set(STOPWORDS)
stopwords.add("said")
stopwords.add("br")
stopwords.add(" ")
stopwords.remove("not")

stopwords.remove("no")
#stopwords.remove("good")
#stopwords.remove("love")
stopwords.remove("like")
#stopwords.remove("best")
#stopwords.remove("!")
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))
```

__ Word Clouds generated from duplicate pair question's text __

```
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.show()
```

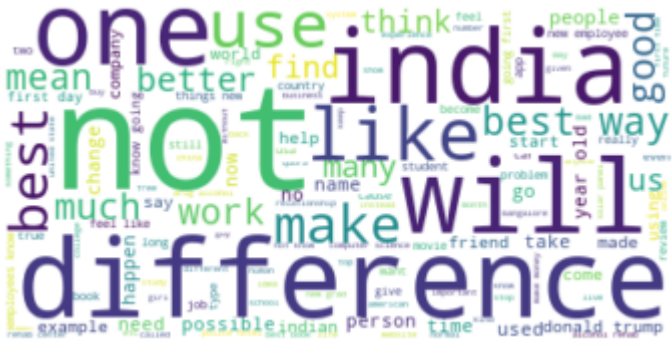
```
Word Cloud for Duplicate Question pairs
```



__ Word Clouds generated from non duplicate pair question's text __

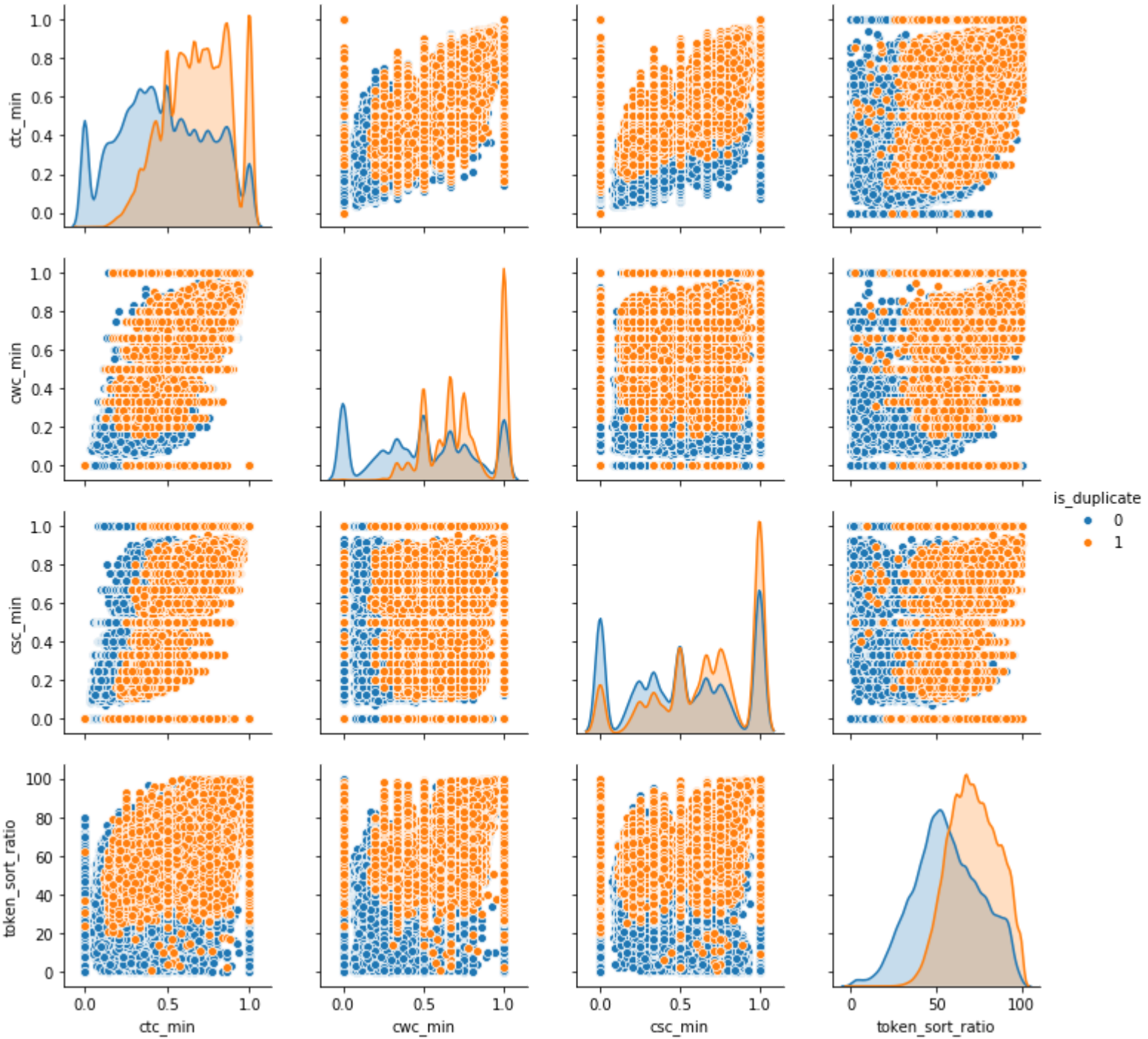
```
wc = WordCloud(background_color="white", max_words=len(textn_w),stopwords=stopwords)
# generate word cloud
wc.generate(textn_w)
print ("Word Cloud for non-Duplicate Question pairs:")
plt.imshow(wc, interpolation='bilinear')
plt.axis("off")
plt.show()
```

```
Word Cloud for non-Duplicate Question pairs:
```

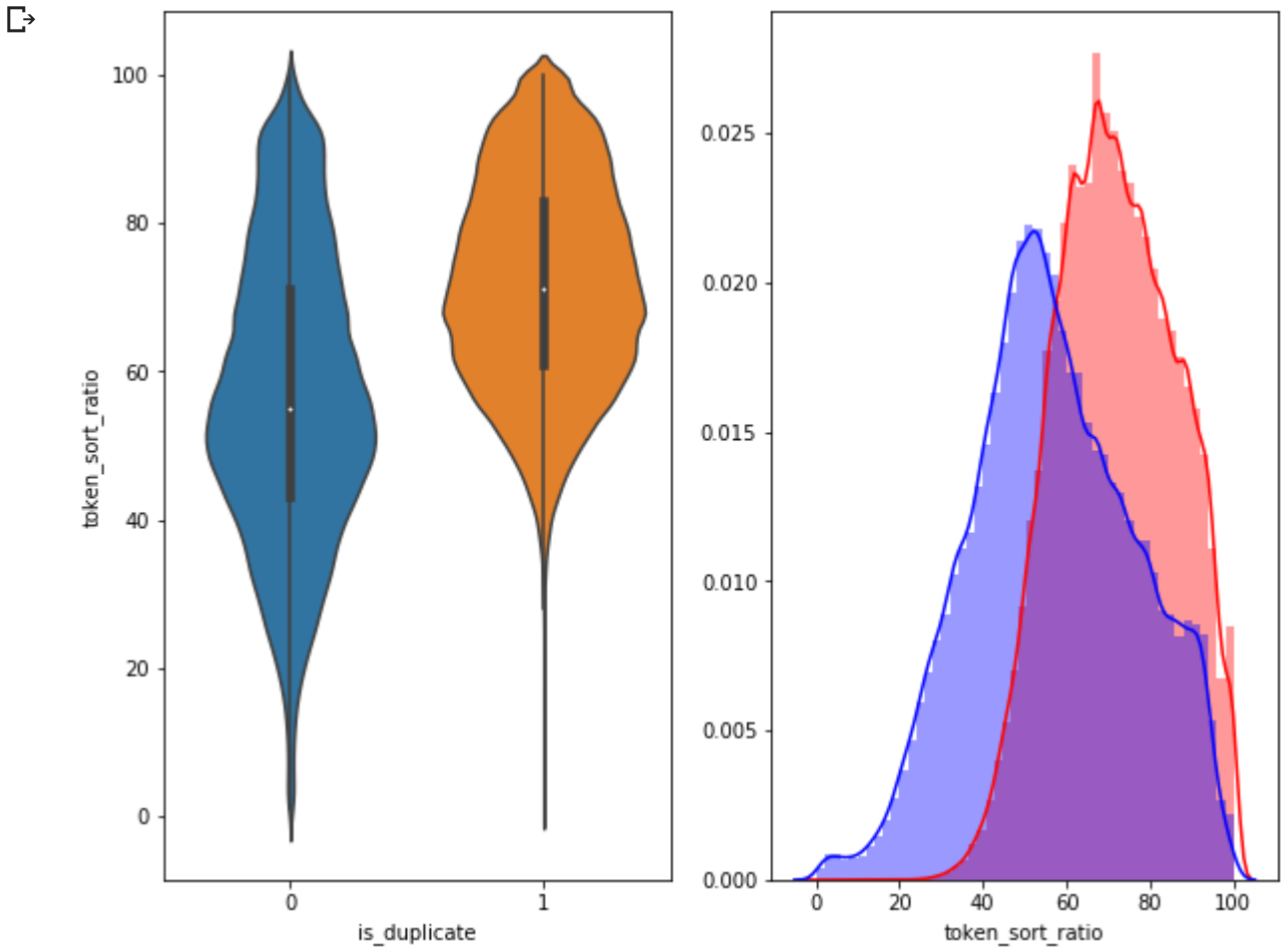


3.5.1.2 Pair plot of features ['ctc_min', 'cwc_min', 'csc_min', 'token_sort_ratio']

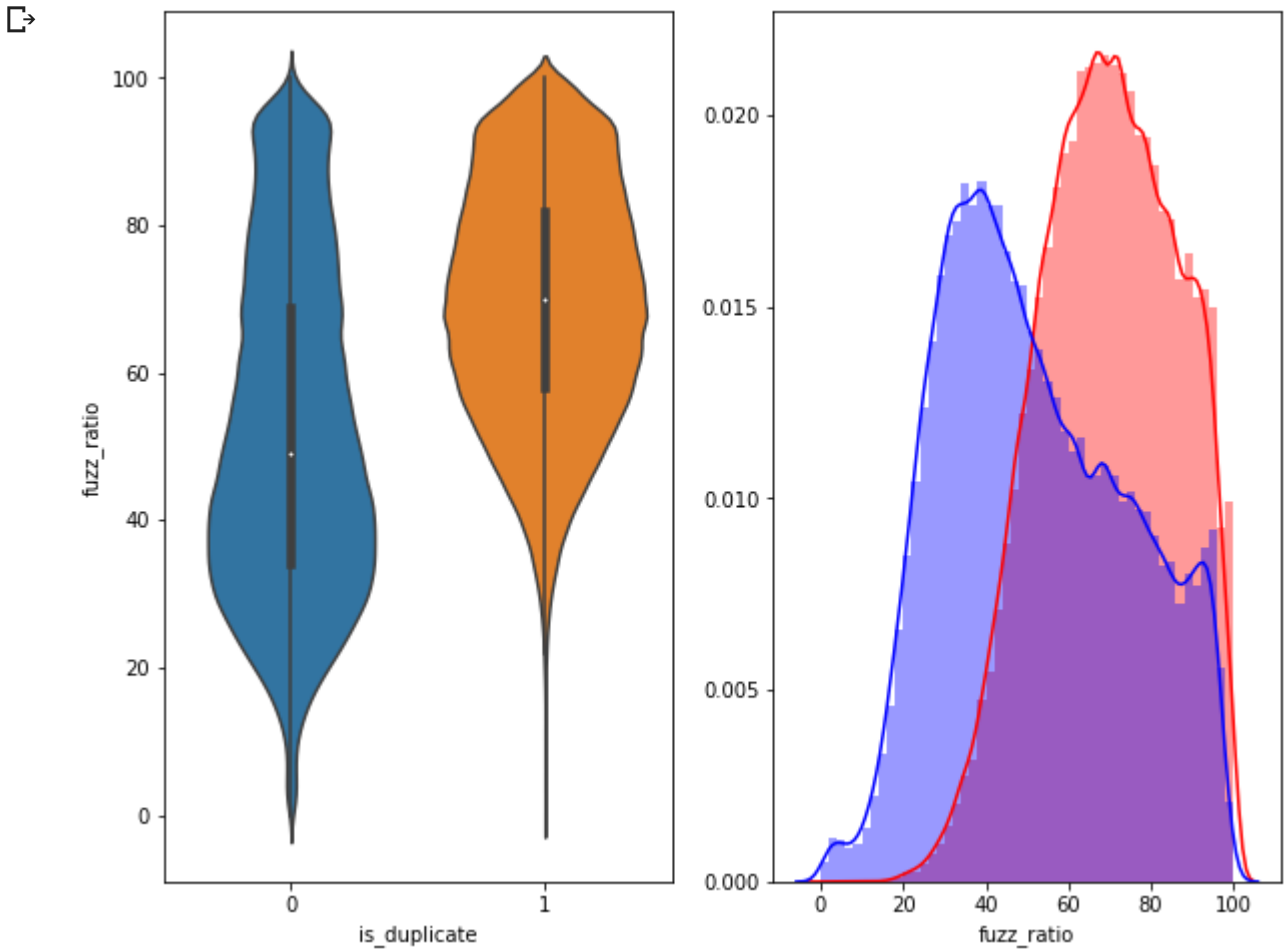
```
n = df.shape[0]
sns.pairplot(df[['ctc_min', 'cwc_min', 'csc_min', 'token_sort_ratio', 'is_duplicate']][0:n], hue='is_duplicate', vars=['ctc_
plt.show()
```


ctc_min
cwc_min
csc_min
token_sort_ratio
is_duplicate
0
1

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

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

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



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

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

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

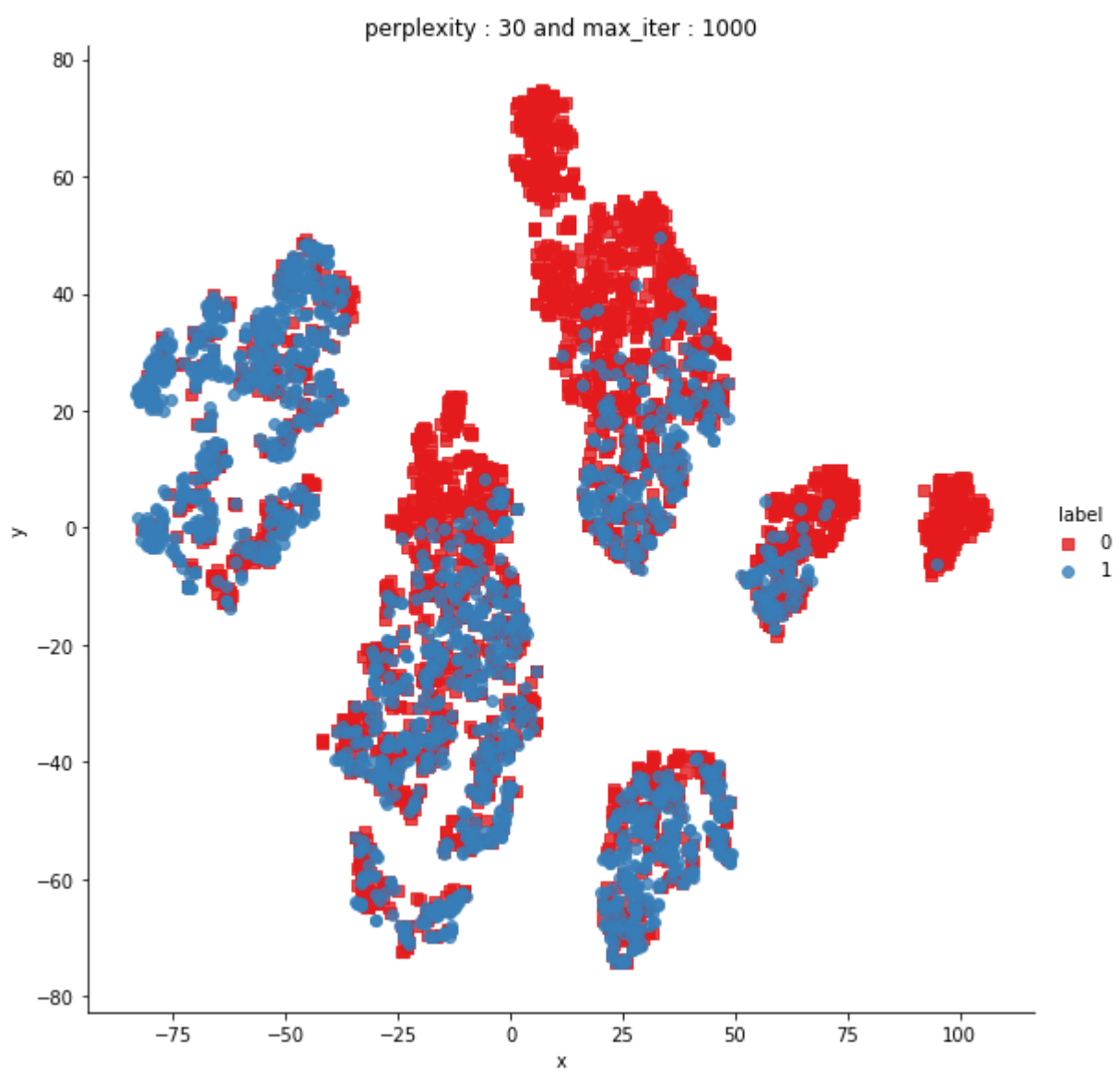


3.5.2 Visualization

```
# Using TSNE for Dimentionality reduction for 15 Features(Generated after cleaning the data) to 3 dimention

from sklearn.preprocessing import MinMaxScaler

dfp_subsampled = df[0:5000]
X = MinMaxScaler().fit_transform(dfp_subsampled[['cwc_min', 'cwc_max', 'csc_min', 'csc_max' , 'ctc_min' , 'ctc_max' , 'last
y = dfp_subsampled['is_duplicate'].values


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 5000 samples in 0.020s...
[t-SNE] Computed neighbors for 5000 samples in 0.435s...
[t-SNE] Computed conditional probabilities for sample 1000 / 5000
[t-SNE] Computed conditional probabilities for sample 2000 / 5000
[t-SNE] Computed conditional probabilities for sample 3000 / 5000
[t-SNE] Computed conditional probabilities for sample 4000 / 5000
[t-SNE] Computed conditional probabilities for sample 5000 / 5000
[t-SNE] Mean sigma: 0.130446
[t-SNE] Computed conditional probabilities in 0.298s
[t-SNE] Iteration 50: error = 81.2911148, gradient norm = 0.0457501 (50 iterations in 2.907s)
[t-SNE] Iteration 100: error = 70.6044159, gradient norm = 0.0086692 (50 iterations in 1.997s)
[t-SNE] Iteration 150: error = 68.9124908, gradient norm = 0.0056016 (50 iterations in 1.882s)
[t-SNE] Iteration 200: error = 68.1010742, gradient norm = 0.0047585 (50 iterations in 1.909s)
[t-SNE] Iteration 250: error = 67.5907974, gradient norm = 0.0033576 (50 iterations in 2.011s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 67.590797
[t-SNE] Iteration 300: error = 1.7929677, gradient norm = 0.0011899 (50 iterations in 1.999s)
[t-SNE] Iteration 350: error = 1.3937442, gradient norm = 0.0004817 (50 iterations in 1.929s)
[t-SNE] Iteration 400: error = 1.2280033, gradient norm = 0.0002773 (50 iterations in 1.915s)
[t-SNE] Iteration 450: error = 1.1383208, gradient norm = 0.0001865 (50 iterations in 1.961s)
[t-SNE] Iteration 500: error = 1.0834006, gradient norm = 0.0001423 (50 iterations in 1.920s)
[t-SNE] Iteration 550: error = 1.0474092, gradient norm = 0.0001144 (50 iterations in 1.942s)
[t-SNE] Iteration 600: error = 1.0231259, gradient norm = 0.0000995 (50 iterations in 1.992s)
[t-SNE] Iteration 650: error = 1.0066353, gradient norm = 0.0000895 (50 iterations in 1.996s)
[t-SNE] Iteration 700: error = 0.9954656, gradient norm = 0.0000805 (50 iterations in 2.014s)
[t-SNE] Iteration 750: error = 0.9871529, gradient norm = 0.0000719 (50 iterations in 2.048s)
[t-SNE] Iteration 800: error = 0.9801921, gradient norm = 0.0000657 (50 iterations in 2.049s)
[t-SNE] Iteration 850: error = 0.9743395, gradient norm = 0.0000631 (50 iterations in 2.018s)
[t-SNE] Iteration 900: error = 0.9693972, gradient norm = 0.0000606 (50 iterations in 2.005s)
[t-SNE] Iteration 950: error = 0.9654404, gradient norm = 0.0000594 (50 iterations in 2.046s)
[t-SNE] Iteration 1000: error = 0.9622302, gradient norm = 0.0000565 (50 iterations in 2.060s)
[t-SNE] KL divergence after 1000 iterations: 0.962230
```

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

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




```
from sklearn.manifold import TSNE
tsne3d = TSNE(
    n_components=3,
    init='random', # pca
    random_state=101,
    method='barnes_hut'
```

```
        method='barnes_hut',
        n_iter=1000,
        verbose=2,
        angle=0.5
    ).fit_transform(X)
```

```
[t-SNE] Computing 91 nearest neighbors...
[t-SNE] Indexed 5000 samples in 0.017s...
[t-SNE] Computed neighbors for 5000 samples in 0.437s...
[t-SNE] Computed conditional probabilities for sample 1000 / 5000
[t-SNE] Computed conditional probabilities for sample 2000 / 5000
[t-SNE] Computed conditional probabilities for sample 3000 / 5000
[t-SNE] Computed conditional probabilities for sample 4000 / 5000
[t-SNE] Computed conditional probabilities for sample 5000 / 5000
[t-SNE] Mean sigma: 0.130446
[t-SNE] Computed conditional probabilities in 0.295s
[t-SNE] Iteration 50: error = 80.5316772, gradient norm = 0.0296611 (50 iterations in 12.797s)
[t-SNE] Iteration 100: error = 69.3823166, gradient norm = 0.0032796 (50 iterations in 5.940s)
[t-SNE] Iteration 150: error = 67.9726028, gradient norm = 0.0016793 (50 iterations in 5.348s)
[t-SNE] Iteration 200: error = 67.4176178, gradient norm = 0.0010922 (50 iterations in 5.414s)
[t-SNE] Iteration 250: error = 67.1033630, gradient norm = 0.0008839 (50 iterations in 5.410s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 67.103363
[t-SNE] Iteration 300: error = 1.5262967, gradient norm = 0.0007234 (50 iterations in 7.186s)
[t-SNE] Iteration 350: error = 1.1826925, gradient norm = 0.0002056 (50 iterations in 9.301s)
[t-SNE] Iteration 400: error = 1.0364963, gradient norm = 0.0000999 (50 iterations in 8.887s)
[t-SNE] Iteration 450: error = 0.9654390, gradient norm = 0.0000914 (50 iterations in 8.905s)
[t-SNE] Iteration 500: error = 0.9289201, gradient norm = 0.0000634 (50 iterations in 8.761s)
[t-SNE] Iteration 550: error = 0.9090494, gradient norm = 0.0000504 (50 iterations in 8.616s)
[t-SNE] Iteration 600: error = 0.8954713, gradient norm = 0.0000525 (50 iterations in 8.360s)
[t-SNE] Iteration 650: error = 0.8866501, gradient norm = 0.0000497 (50 iterations in 8.455s)
[t-SNE] Iteration 700: error = 0.8820391, gradient norm = 0.0000369 (50 iterations in 8.639s)
[t-SNE] Iteration 750: error = 0.8775222, gradient norm = 0.0000342 (50 iterations in 8.623s)
[t-SNE] Iteration 800: error = 0.8723416, gradient norm = 0.0000288 (50 iterations in 8.624s)
[t-SNE] Iteration 850: error = 0.8663230, gradient norm = 0.0000297 (50 iterations in 8.613s)
[t-SNE] Iteration 900: error = 0.8605922, gradient norm = 0.0000286 (50 iterations in 8.629s)
[t-SNE] Iteration 950: error = 0.8555549, gradient norm = 0.0000312 (50 iterations in 8.675s)
[t-SNE] Iteration 1000: error = 0.8521745, gradient norm = 0.0000278 (50 iterations in 8.608s)
[t-SNE] KL divergence after 1000 iterations: 0.852175
```

```
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')
```