Load Data

The goal of this project is to predict which of the provided pairs of questions contain two questions with the same meaning. The ground truth is the set of labels that have been supplied by human experts. The ground truth labels are inherently subjective, as the true meaning of sentences can never be known with certainty. Human labeling is also a 'noisy' process, and reasonable people will disagree. As a result, the ground truth labels on this dataset should be taken to be 'informed' but not 100% accurate, and may include incorrect labeling. We believe the labels, on the whole, to represent a reasonable consensus, but this may often not be true on a case by case basis for individual items in the dataset.

```
# !pip install opendatasets
```

```
# import opendatasets as od
# url = "https://www.kaggle.com/c/quora-question-pairs/data"
# od.download(url)
```

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
```

```
df = pd.read_csv("/kaggle/input/quora-question-pairs/train.csv.zip")
```

EDA

```
# Structure of data
df.shape
```

```
(404290, 6)
```

```
# Duplicate questions data
df[df["id"] == 244500]
```

	id	qid1	qid2	question1	question2	is_duplicate
244500	244500	24118	13778	What do you think of the Government's move of ...	What do you think will be the effect of Modi G...	1

```
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
```

```
# Null value in datset
df.isnull().sum()
```

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

```
# Duplicate value in dataset
df.duplicated().sum()
```

```
0
```

```
# Distribution of Duplicate and Non-duplicate questions
df["is_duplicate"].value_counts()
```

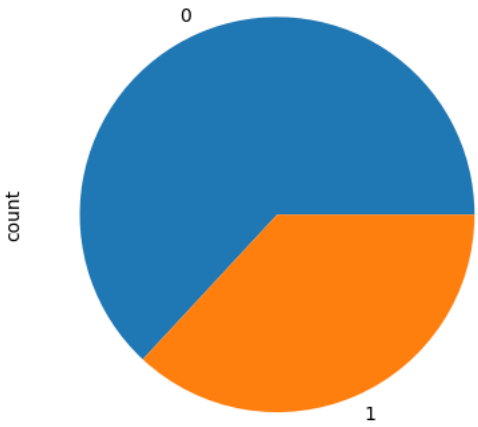
```
is_duplicate
0    255027
1    149263
Name: count, dtype: int64
```

```
# Percentage Distribution of Duplicate and Non-duplicate questions
df["is_duplicate"].value_counts() / df["is_duplicate"].count() *100
```

```
is_duplicate
0    63.080215
1    36.919785
Name: count, dtype: float64
```

```
df["is_duplicate"].value_counts().plot(kind = "pie")
```

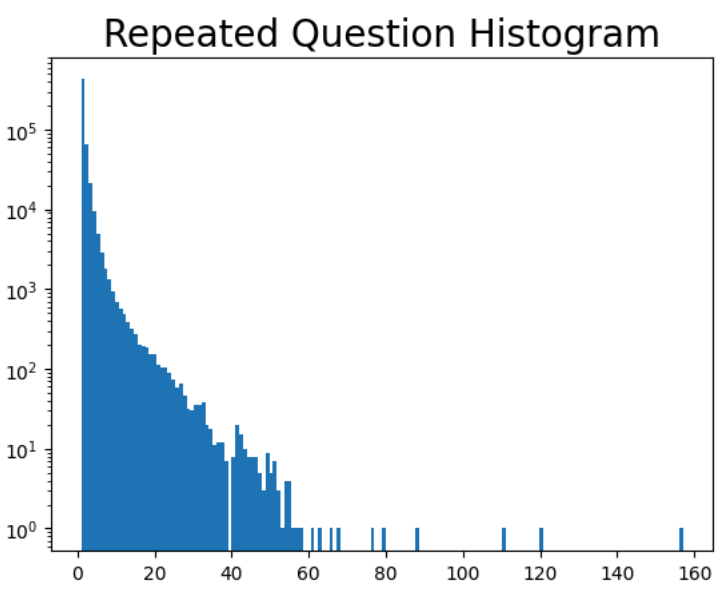
```
<Axes: ylabel='count'>
```




```
# repeated question
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
```

```
# repeated question histograme
plt.hist(qid.value_counts() , bins = 160)
plt.yscale("log")
plt.title("Repeated Question Histogram" , size = 20)
plt.show()
```



Summary -

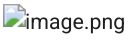
- As per our histogram unique question are in our datset are `10^5 ~ 5 lakhs`
- There is one question in our dataseyt which is repeated `120` times
- If we carryfully look at graph,Seems like there is one question which is almost repeated `~156 times`
- Most of the question in our datset are repeated approx 20 or 60 times

TF-IDF

TF-IDF (Term Frequency–Inverse Document Frequency) is a statistical method used in natural language processing and information retrieval to evaluate how important a word is to a document in relation to a larger collection of documents. TF-IDF combines two components:

1. Term Frequency (TF): Measures how often a word appears in a document. A higher frequency suggests greater importance. If a term appears frequently in a document, it is likely relevant to the document's content

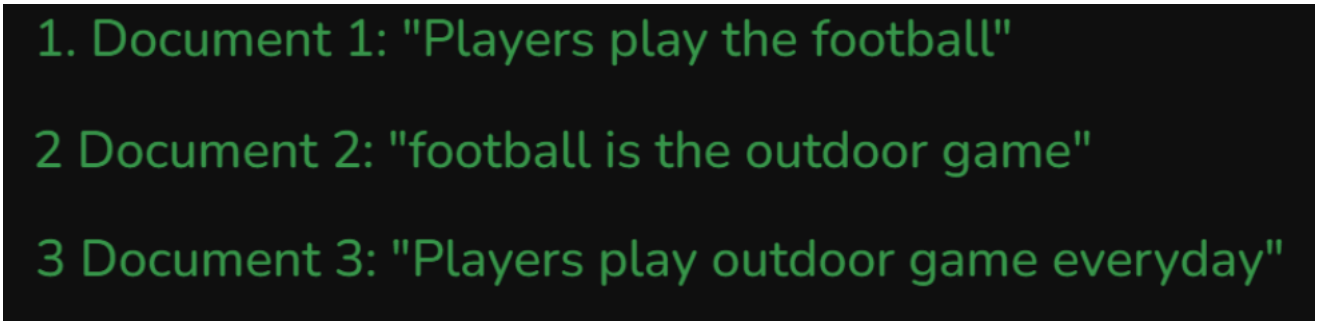
$$TF(t, d) = \frac{\text{Number of times term t appears in document d}}{\text{Total number of terms in document d}}$$



3. Inverse Document Frequency (IDF): Reduces the weight of common words across multiple documents while increasing the weight of rare words. If a term appears in fewer documents, it is more likely to be meaningful and specific.

$$IDF(t, D) = \log \frac{\text{Total number of documents in corpus D}}{\text{Number of documents containing term t}}$$

Now let's understand with few example how TF IDF works?



Our goal is to calculate the TF-IDF score for specific terms in these documents. Let's focus on the word "football" and see how TF-IDF evaluates its importance

Step 1 : Calculate Term Ferquency(TF)

For Document 1:

- The word "football" appear 1 time
- The total number of terms in Document 1 is 4 ("Players" , "play" , "the" , "football")
- so Now TF of football would be : TF(football , Document1) = 1 / 4

For Document 2:

- The word "football" appear 1 time
- The total number of terms in Document 2 is 5 ("football" , "is" , "the" , "outdoor" , "game")
- so Now TF of football would be : TF(football , Document2) = 1 / 5

For Document 3:

- The word "football" appear 0 time
- The total number of terms in Document 1 is 5 ("Players" , "play" , "outdoor" , "game" ,"everyday")
- so Now TF of football would be : TF(football , Document3) = 0

Step 2 : Calculate Inverse Document Frequency (IDF))

- Total Number of Documents in the corpus (D) : 3
- Number of documents containing the term "football" : 2 (Document 1 , Documnet 2)
- IDF(football , D) = log 3/2 = 0.176

The TF-IDF score is the product of TF and IDF:

$$TF - IDF(t, d, D) = TF(t, d) \times IDF(t, D)$$

- For Document 1: TF-IDF (football, Document 1, D): 0.25 * 0.176 = 0.044
- For Document 2: TF-IDF(football, Document 2, D): 0.2x 0.176 = 0.0352
- For Document 3: TF-IDF (football, Document 3, D): 0 x 0.176 = 0

```
df.shape
```

```
(404290, 6)
```

```
# consider only 10000 samples of data
new_df = df.sample(10000)
```

```
ques_df = new_df[["question1" , "question2"]]
ques_df.head()
```

	question1	question2
284201	I never get satisfied with my decisions. What ...	Are we all time travelers?
234861	What is your best memory of a stranger?	What's your best memories that happened with a...
3887	What is document cryptography?	What is cryptography?
375363	Does anyone know of any good barbershop websit...	Barbershops: Are barber shops profitable?
199335	What are bad habits?	What are really bad habits?

```
question = list(ques_df["question1"]) + list(ques_df["question2"])
```

```
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf = TfidfVectorizer(
    analyzer = "word" ,
    stop_words = ("english") ,
    ngram_range = (2,2) ,
    max_features = 3000,
    binary = True

)
```

```
q1_arr  , q2_arr = np.vsplit(tfidf.fit_transform(question).toarray() , 2)
```

```
print(tfidf.get_feature_names_out())
print(tfidf.idf_)
```

```
['000 views' '10 000' '10 best' ... 'youtube video' 'youtube videos'
 'yr old']
[9.29409964 9.11177808 9.29409964 ... 8.4186309  8.70631297 9.51724319]
```

```
tfidf.vocabulary_
```

```
{'does know': 785,
 'bad habits': 175,
 'look like': 1648,
 'time travel': 2648,
 'int printf': 1427,
 'printf output': 2136,
 'output statement': 1982,
 'long does': 1643,
 'long time': 1646,
 'use everyday': 2732,
 'significance battle': 2380,
 'battle somme': 196,
 'somme did': 2431,
 'did battle': 693,
```

```
 'battle compare': 195,
 'compare contrast': 569,
 'contrast battle': 586,
 'viewed instagram': 2775,
 'roman empire': 2267,
 'wave particle': 2848,
 'particle duality': 2000,
 'cheapest painless': 493,
 'painless easiest': 1987,
 'easiest way': 884,
 'way commit': 2853,
 'commit suicide': 552,
 'tips making': 2651,
 'making job': 1716,
 'job interview': 1481,
 'interview process': 1439,
 'chances getting': 474,
 'getting job': 1128,
 'students studying': 2533,
 'worst thing': 2968,
 'differences chinese': 725,
 'chinese western': 510,
 'science fair': 2318,
 'fair project': 1022,
 'enhance english': 967,
 'english language': 955,
 'agile approach': 91,
 'data science': 634,
 'unusual aspects': 2720,
 'aspects politics': 149,
 'politics government': 2096,
 'interesting topics': 1434,
 'important thing': 1331,
 'thing life': 2603,
 'balaji viswanathan': 180,
 '500 1000': 59,
 '1000 rupees': 14,
 'currency notes': 614,
 'best jokes': 270,
 'best institute': 267,
 'institute ca': 1420,
 'best thing': 315,
 'bengali girls': 209,
 'best book': 228
```

```
tfidf.max_features
```

```
3000
```

```
temp_df1 = pd.DataFrame(q1_arr , index = ques_df.index)
temp_df2 = pd.DataFrame(q2_arr , index = ques_df.index)
temp_df_tf = pd.concat([temp_df1 , temp_df2])
print(temp_df1.shape)
print(temp_df2.shape)
print(temp_df_tf.shape)
```

```
(10000, 3000)
(10000, 3000)
(20000, 3000)
```

```
temp_df_tf["is_duplicate"] =  new_df["is_duplicate"]
```

```
# Splitting the data
from sklearn.model_selection import train_test_split
x_train  , x_test , y_train , y_test = train_test_split(temp_df_tf.iloc[: , 0:-1] , temp_df_tf.iloc[: , -1] , test_size = 0.2 , random_s
```

```
from sklearn.ensemble import RandomForestClassifier
rf_tf = RandomForestClassifier()
rf_tf.fit(x_train , y_train)
```

```
RandomForestClassifier
RandomForestClassifier()
```

```
from sklearn.metrics import accuracy_score
y_pred = rf_tf.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_pred , y_test))
```

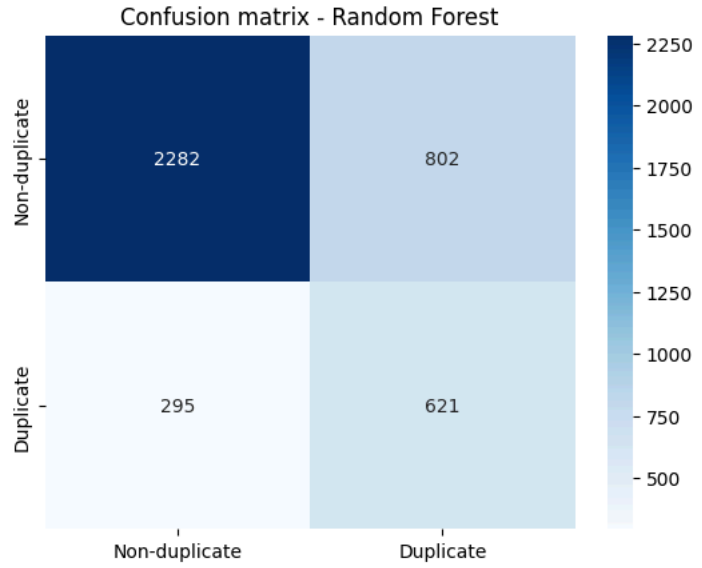
```
Accuracy Score -  0.72575
```

```
from sklearn.metrics import confusion_matrix
rf_cf = confusion_matrix(y_pred , y_test)
rf_cf
```

```
array([[2282,  802],
       [ 295,  621]])
```

```
# Random Forest confusion matrix
# cmap=plt.cm.copper
sns.heatmap(rf_cf  , annot=True  , fmt = "d" , cmap = "Blues" , xticklabels=["Non-duplicate" , "Duplicate"] , yticklabels=["Non-duplicat
plt.title("Confusion matrix - Random Forest" , fontsize = 12)
```

```
Text(0.5, 1.0, 'Confusion matrix - Random Forest')
```



- True Negative (TN): 2282

  Model correctly predicted "not duplicate" for actual "not duplicate" questions.

- False Positive (FP): 802

  Model predicted "duplicate" when the actual was "not duplicate." This is a cost, as these are incorrectly marked as duplicates.

- False Negative (FN): 295

  Model predicted "not duplicate" when the actual was "duplicate." This is also a loss since real duplicate questions are missed.

- True Positive (TP): 621

  Model correctly predicted "duplicate" for actual "duplicate" questions.

```
from xgboost import XGBClassifier
XG_tf = XGBClassifier()
XG_tf.fit(x_train , y_train)
```

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              multi_strategy=None, n_estimators=None, n_jobs=None,
              num_parallel_tree=None, random_state=None, ...)
```

```
y_pred = XG_tf.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_test , y_pred))
```

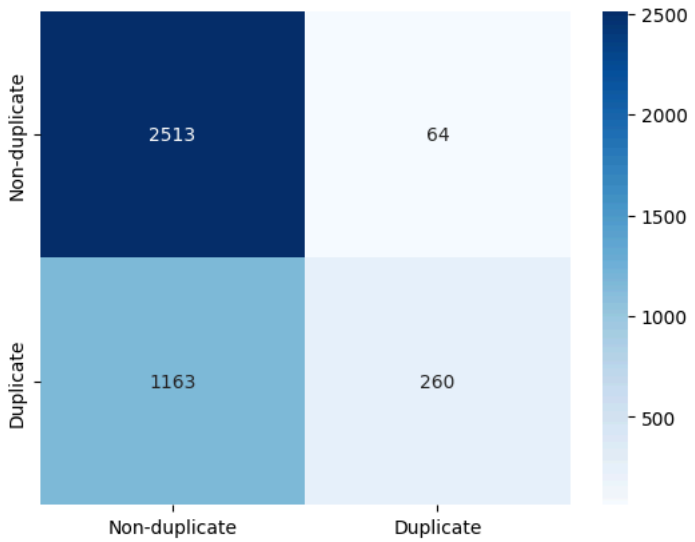
```
Accuracy Score -  0.69325
```

```
XG_cf = confusion_matrix(y_test , y_pred)
XG_cf
```

```
array([[2513,   64],
       [1163,  260]])
```

```
sns.heatmap(XG_cf , annot = True , fmt = "d" , cmap = "Blues"  , xticklabels=["Non-duplicate" , "Duplicate"] , yticklabels=["Non-duplica
```

```
<Axes: >
```



- True Negative (TN): 2513

  Model correctly predicted "not duplicate" on truly "not duplicate" pairs.

- False Positive (FP): 64

  Model incorrectly predicted "duplicate" on "not duplicate" pairs. These are “lost” predictions.

- False Negative (FN): 1163

  Model incorrectly predicted "not duplicate" on "duplicate" pairs—a significant loss

- True Positive (TP): 260

  Model correctly predicted "duplicate" on truly "duplicate" pairs—a “benefit.”

```
from sklearn.tree import DecisionTreeClassifier
dt_tf = DecisionTreeClassifier(
    criterion = "gini" ,
    max_depth = 99 ,
    max_features  = "sqrt" ,

)
dt_tf.fit(x_train , y_train)
```

```
DecisionTreeClassifier(max_depth=99, max_features='sqrt')
```

```
y_pred = dt_tf.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_pred , y_test))
```

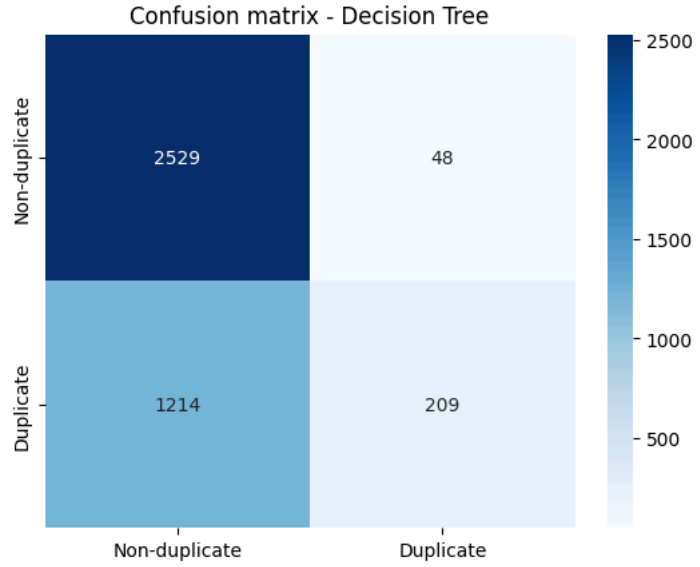
```
Accuracy Score -  0.6845
```

```
dt_cf = confusion_matrix(y_test , y_pred)
dt_cf
```

```
array([[2529,   48],
       [1214,  209]])
```

```
sns.heatmap(dt_cf , annot = True , fmt = "d" , cmap = "Blues" , xticklabels=["Non-duplicate" , "Duplicate"] , yticklabels=["Non-duplicate
plt.title("Confusion matrix - Decision Tree")
```

```
Text(0.5, 1.0, 'Confusion matrix - Decision Tree')
```



- True Negatives (TN): 2529

  Model correctly predicted non-duplicate pairs as not duplicate.
- False Positives (FP): 48

  Model incorrectly predicted non-duplicate pairs as duplicate.
- False Negatives (FN): 1214

  Model incorrectly predicted duplicate pairs as not duplicate.
- True Positives (TP): 209

  Model correctly predicted duplicate pairs as duplicate

```
# cross validation
from sklearn.model_selection import cross_val_score
rf_tf_cross = cross_val_score(rf_tf , x_train  , y_train , cv = 5)
print("Random Forest Cross Validation Score :" , round(rf_tf_cross.mean() *100 , 2).astype("str") + "%")
```

```
Random Forest Cross Validation Score : 71.61%
```

```
xg_tf_cross = cross_val_score(XG_tf , x_train  , y_train , cv = 5)
print("XGBoost Cross Validation Score - " , round(xg_tf_cross.mean() * 100 , 2).astype("str") + "%")
```

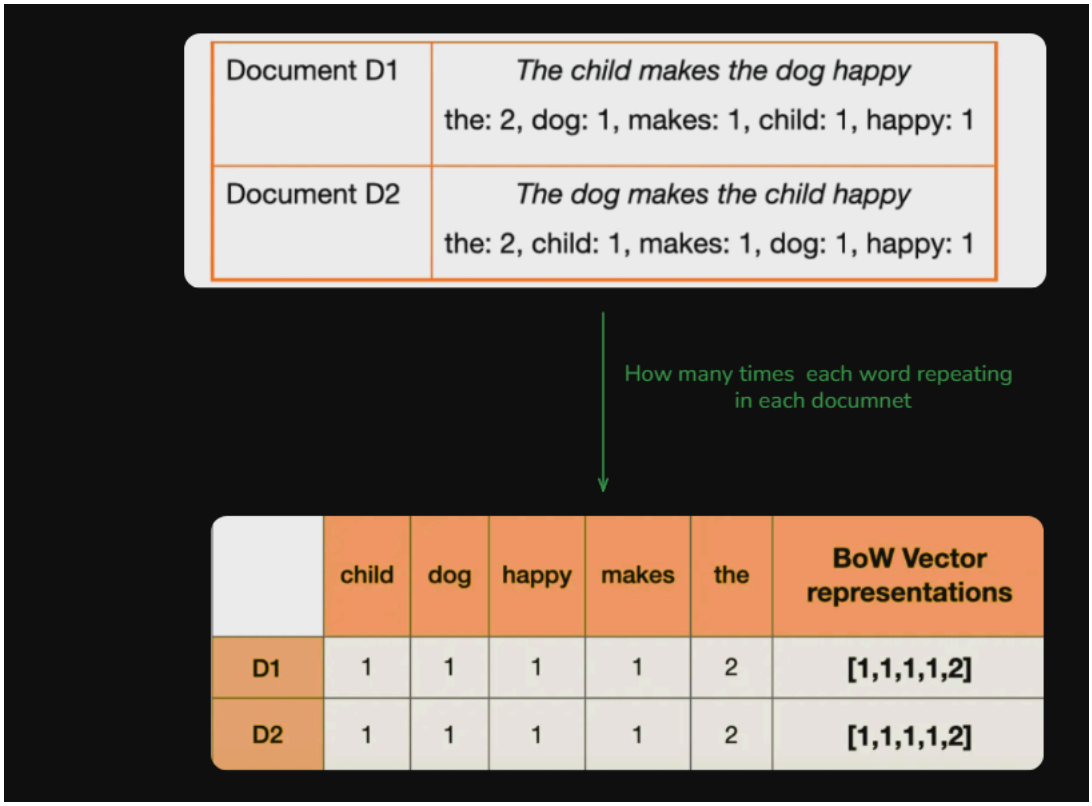
```
XGBoost Cross Validation Score -  68.22%
```

```
dt_tf_cross = cross_val_score(dt_tf , x_train  , y_train , cv = 5)
print("Decision Tree Cross Validation Score - " , round(dt_tf_cross.mean() * 100 , 2).astype("str") + "%")
```

```
Decision Tree Cross Validation Score -  67.46%
```

Bag-of-words

In Natural Language Processing (NLP) text data needs to be converted into numbers so that machine learning algorithms can understand it. One common method to do this is Bag of Words (BoW) model. It turns text like sentence, paragraph or document into a collection of words and counts how often each word appears but ignoring the order of the words. It does not consider the order of the words or their grammar but focuses on counting how often each word appears in the textIn Natural Language Processing (NLP) text data needs to be converted into numbers so that machine learning algorithms can understand it. One common method to do this is Bag of Words (BoW) model. It turns text like sentence, paragraph or document into a collection of words and counts how often each word appears but ignoring the order of the words. It does not consider the order of the words or their grammar but focuses on counting how often each word appears in the text




```
df.shape
```

```
(404290, 6)
```

```
# consider only 10000 data
new_df = df.sample(10000)
```

```
# Is there any null value present?
new_df.isnull().sum()
```

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

```
# Is there any duplicate data present?
new_df.duplicated().sum()
```

```
0
```

```
ques_df = new_df[["question1" , "question2"]]
ques_df.head()
```

	question1	question2
353221	How do I follow up with someone in WhatsApp?	How can I follow someone on WhatsApp?
185933	How can I get a meeting with Elon Musk?	How can I meet Elon Musk?
262198	Can I make 60,000 a month playing poker?	Can I make thousands a month playing poker?
65873	What are the indicators of a developing country?	What is the development of a country and What ...
95363	How do ammonia and sodium hydroxide react?	How do zinc oxide and sodium hydroxide react?

```
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)
```

```
# 3000 featurename
cv.get_feature_names_out()
```

```
array(['000', '10', '100', ..., 'zealand', 'zero', 'zone'], dtype=object)
```

```
# Vacabulary
cv.vocabulary_
```


```
{'how': 1303,
 'do': 793,
 'follow': 1063,
 'up': 2805,
 'with': 2949,
 'someone': 2475,
 'in': 1349,
 'whatsapp': 2920,
 'can': 436,
 'get': 1145,
 'meeting': 1675,
 'make': 1616,
 '60': 50,
 '000': 0,
 'month': 1733,
 'playing': 2002,
 'poker': 2012,
 'what': 2918,
 'are': 209,
 'the': 2676,
 'of': 1836,
 'developing': 753,
 'country': 641,
 'and': 166,
 'sodium': 2463,
 'react': 2170,
 'invest': 1400,
 'city': 531,
 'enterprise': 915,
 'solutions': 2471,
 '10': 1,
 'greatest': 1196,
 'you': 2992,
 've': 2835,
 'got': 1176,
 '24': 32,
 'hours': 1301,
 'to': 2716,
 'live': 1564,
 'will': 2937,
 'spend': 2503,
 'your': 2994,
 'last': 1500,
 'day': 699,
 'on': 1853,
 'earth': 847,
 'become': 306,
 'millionaire': 1704,
 'is': 1416,
 'does': 798,
 'chinese': 519,
 'phrase': 1966,
 'mean': 1663,
 'motivate': 1743,
 'yourself': 2995,
 'work': 2959,
 'hard': 1238,
 'understand': 2788,
```


```
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])
temp_df.shape
#  5000 feature from question 1 +  5000 feature from question 2 == 10000 features
```

```
(20000, 3000)
```

```
temp_df
```

	0	1	2	3	4	5	6	7	8	9	...	2990	2991	2992	2993	2994	2995	2996	2997	2998	2999
353221	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
185933	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
262198	1	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
65873	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
95363	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
277312	0	0	0	0	0	0	0	0	0	0	...	0	0	1	0	0	0	0	0	0	0
201562	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
346798	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
195101	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
385307	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

20000 rows × 3000 columns

```
temp_df["is_duplicate"] = new_df["is_duplicate"]
```

```
temp_df
```

	0	1	2	3	4	5	6	7	8	9	...	2991	2992	2993	2994	2995	2996	2997	2998	2999	is_duplicate
353221	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	1
185933	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	1
262198	1	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
65873	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
95363	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
277312	0	0	0	0	0	0	0	0	0	0	...	0	1	0	0	0	0	0	0	0	0
201562	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	1
346798	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
195101	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
385307	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

20000 rows × 3001 columns

```
# Splitting data into 80-20 %
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] , test_size = 0.2 , random_s
```

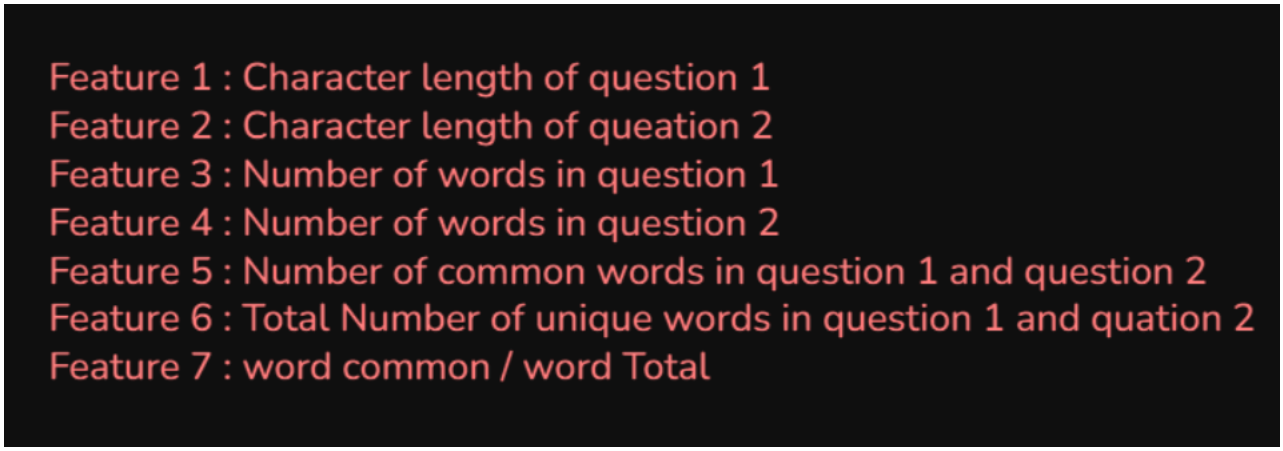
```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score , precision_score , recall_score
rf = RandomForestClassifier()
rf.fit(x_train , y_train)
y_pred = rf.predict(x_test)
print("Accuracy sCore - " , accuracy_score(y_test , y_pred))
```

```
Accuracy sCore -  0.747
```

```
from xgboost import XGBClassifier
xgb = XGBClassifier()
xgb.fit(x_train  , y_train)
y_pred = xgb.predict(x_test)
print("Accuracy Score  - " , accuracy_score(y_pred, y_test))
```

```
Accuracy Score  -  0.72025
```

BOW - Basic features / Feature Engneering




```
# 1 -  lengh of  question 1
# 2 -  lengh of  question 2
# 3 -  No words in question 1
# 4 -  No words in question 2
# 5 -  No of common words in question 1 + question 2
# 6 -  Total Number of unique words in question 1 + question 2
# 7 -  word common / word Total
```

```
Start coding or generate with AI.
```

```
new_df = df.sample(30000 , random_state = 2)
```

```
# Is there any null value present?
new_df.isnull().sum()
```

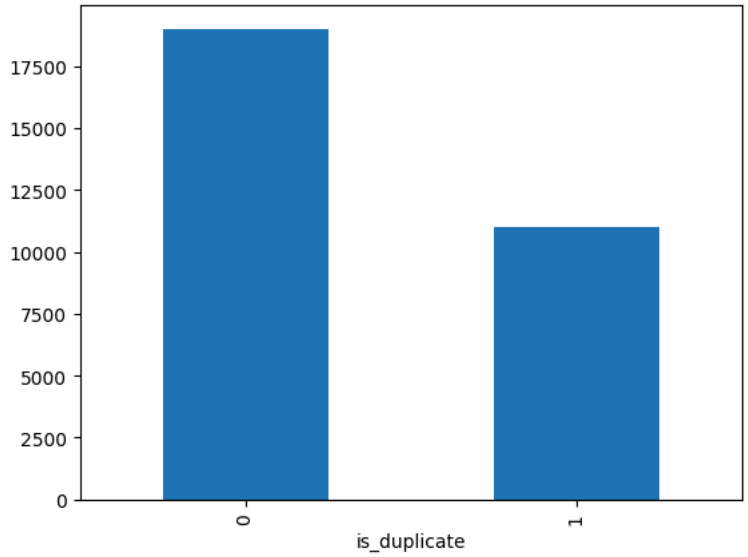
```
id              0
qid1            0
qid2            0
question1       0
question2       0
is_duplicate    0
dtype: int64
```

```
# Is there any duplicate data present
new_df.duplicated().sum()
```

```
0
```

```
# Distribution of duplicate and non-deuplicate questions
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')
```

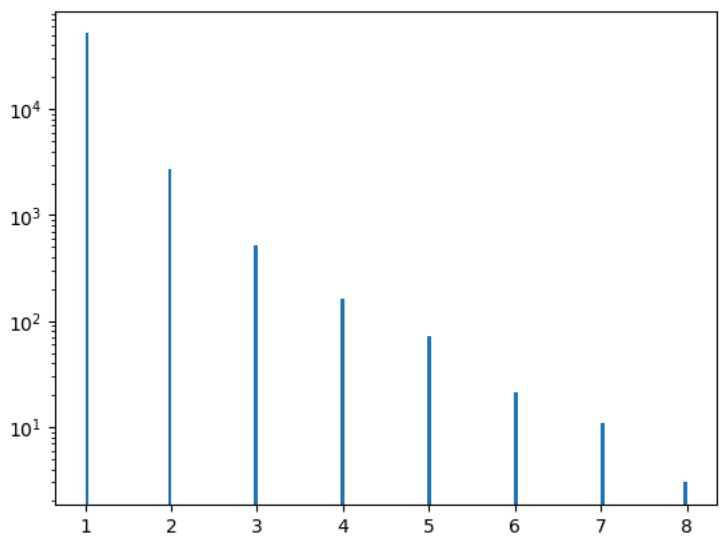
```
is_duplicate
0    19013
1    10987
Name: count, dtype: int64
is_duplicate
0    63.376667
1    36.623333
Name: count, dtype: float64
<Axes: xlabel='is_duplicate'>
```




```
# 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
```

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



Feature Engineering

- feature 1 - lengh of question 1
- feature 2 - lengh of question 2

```
# Feature 1 and Feature 2
new_df["q1_len"] = new_df["question1"].str.len()
new_df["q2_len"] = new_df["question2"].str.len()
```

```
new_df.head()
```

	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
				Why do so many people in the U.S. hate	My boyfriend doesnt feel guilty when he			

- feature 3 - Number words in question 1
- feature 4 - Number words in question 2

```
# Feature 3 and Feature 4
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(1)
```

	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	What is the best marketing automation	1	76	77	12	12

feature 5 - Number of common words in question 1 + question 2

```
# feature 5 Number of common words in question 1 and question 2
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)
```

```
new_df["word_common"] = new_df.apply(common_words , axis = 1)
```

```
new_df.head(1)
```

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common
				What is the best marketing	What is the best marketing						

feature 6 - Total Number of unique words in question 1 + question 2

```
# feature 6 Total Number of unique words in question 1 and question 2
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))
```

```
new_df["word_total"] = new_df.apply(total_words , axis = 1)
```

```
new_df.head(1)
```

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_to
				What is the best	What is the best							

feature 7 - word_share = word common / word Total

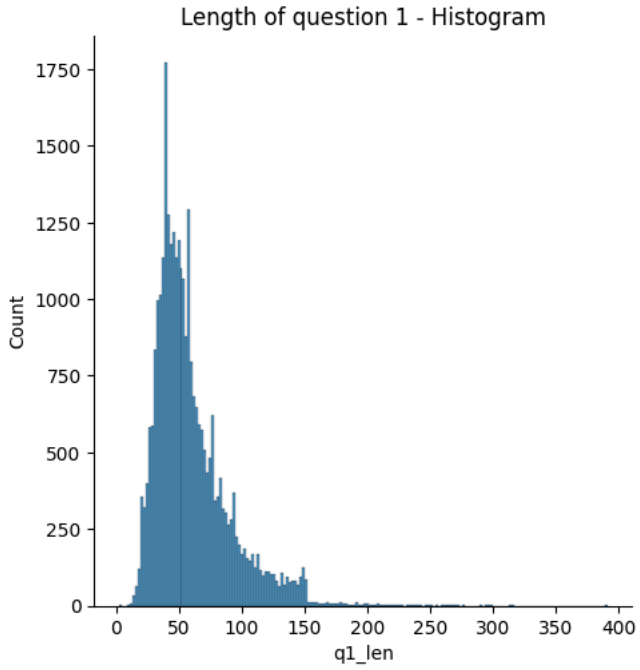
```
# Feature 7
new_df["word_share"] = round(new_df["word_common"] / new_df["word_total"] , 2)
```

```
new_df.head(1)
```

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	word_to
				What is the best	What is the best							

```
# Anlalysiz of feature
sns.displot(new_df["q1_len"])
plt.title("Length of question 1 - Histogram")
print("minimum characters " , new_df["q1_len"].min())
print("maximum characters " , new_df["q1_len"].max())
print("average number of characters " , round(new_df["q1_len"].mean() , 2))
```

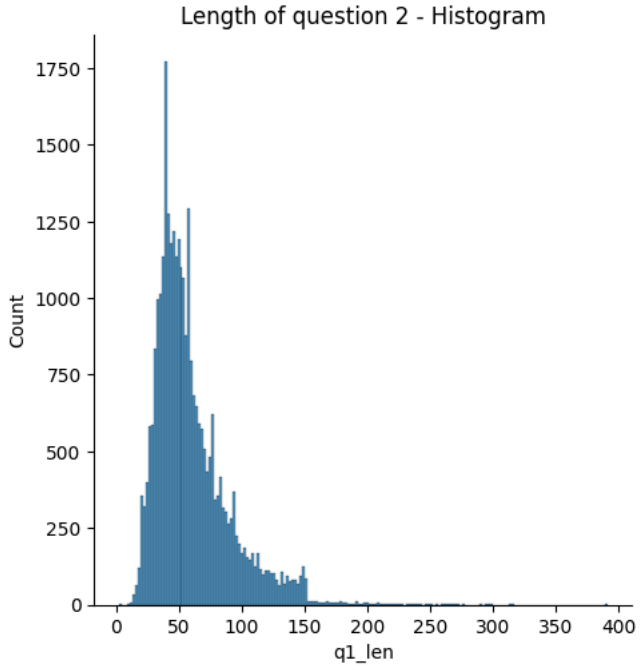
```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
minimum characters  2
maximum characters  391
average number of characters  59.71
```



- Most of the question length of question 1 lies between 5-150
- Few question are there having a more than 200 length

```
sns.displot(new_df["q1_len"])
plt.title("Length of question 2 - Histogram")
print("minimum characters " , new_df["q2_len"].min())
print("maximum characters " , new_df["q1_len"].max())
print("average number of characters " , round(new_df["q2_len"].mean() , 2))
```

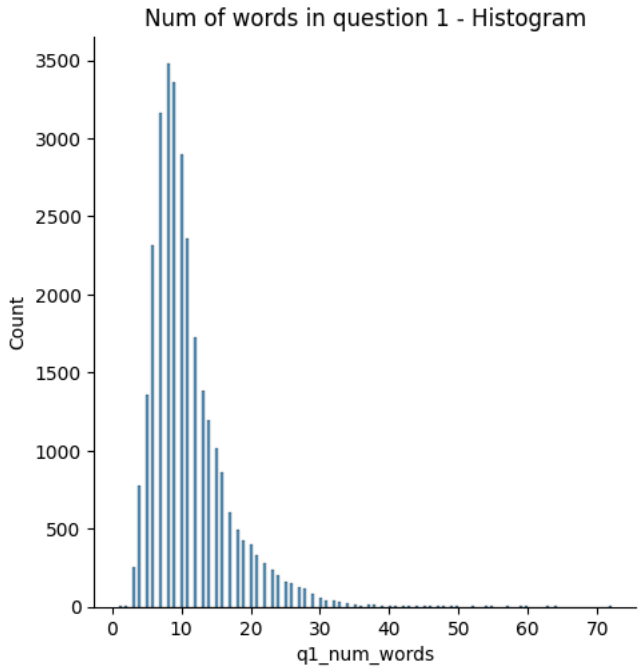
```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
minimum characters  6
maximum characters  391
average number of characters  60.29
```



- Same as question 1 question 2 length of question is lies between 5-150
- Some few question are there having a more than 150 length

```
sns.displot(new_df["q1_num_words"])
plt.title("Num of words in question 1 - Histogram")
print("minimum words" , new_df["q1_num_words"].min())
print("maximum words" , new_df["q1_num_words"].max())
print("average number of words" , round(new_df["q1_num_words"].mean(),2))
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
minimum words 1
maximum words 72
average number of words 10.97
```



Main Distribution:

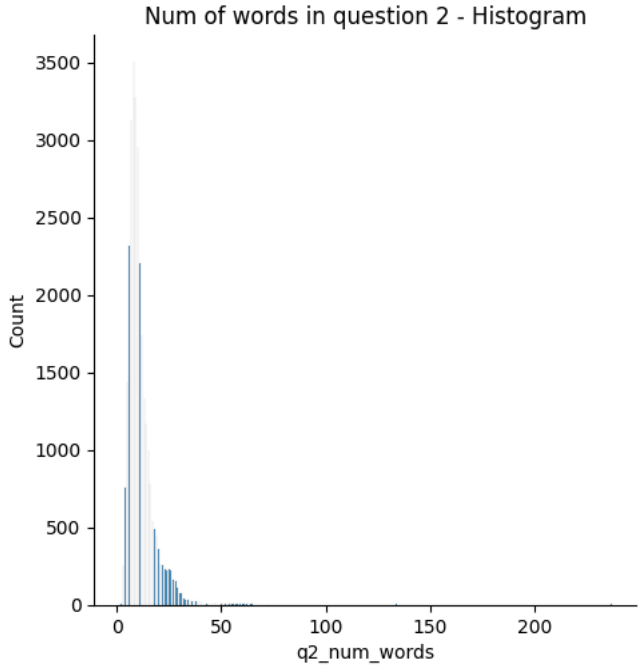
- The concentration of word counts in the 5–30 range suggests that users generally ask brief and direct questions, reflecting common behavior in many text-based

Long Tail:

- The small number of questions with more than 30 words forms a long tail in the histogram. These are likely outlier questions that are either very detailed, multi-part, or possibly poorly structured

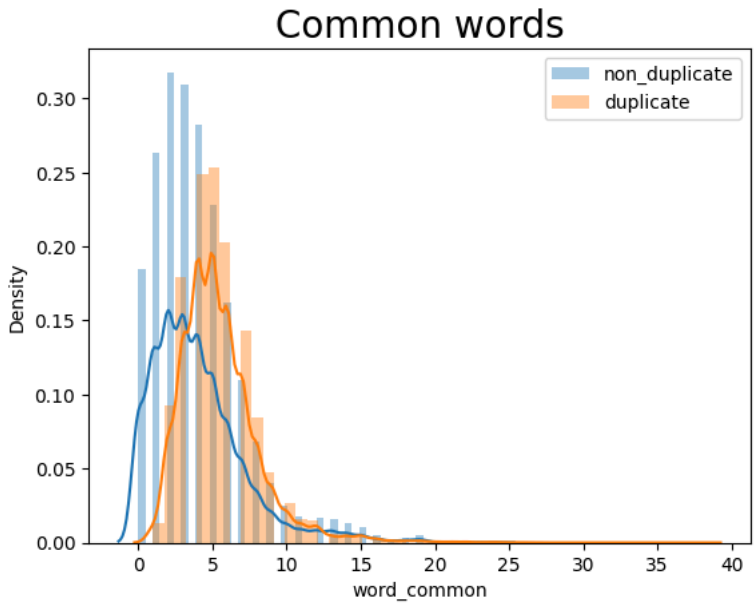
```
sns.displot(new_df["q2_num_words"])
plt.title("Num of words in question 2 - Histogram")
print("minimum words" , new_df["q2_num_words"].min())
print("maximum words" , new_df["q2_num_words"].max())
print("average number of words" , round(new_df["q2_num_words"].mean(),2))
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
minimum words 1
maximum words 237
average number of words 11.23
```




```
# 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.title("Common words" , size = 20)
plt.legend()
plt.show()
```

```
/tmp/ipykernel_36/2731693711.py:2: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(new_df[new_df["is_duplicate"] == 0]["word_common"] , label = "non_duplicate")
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/tmp/ipykernel_36/2731693711.py:3: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(new_df[new_df["is_duplicate"] == 1]["word_common"] , label = "duplicate")
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
```

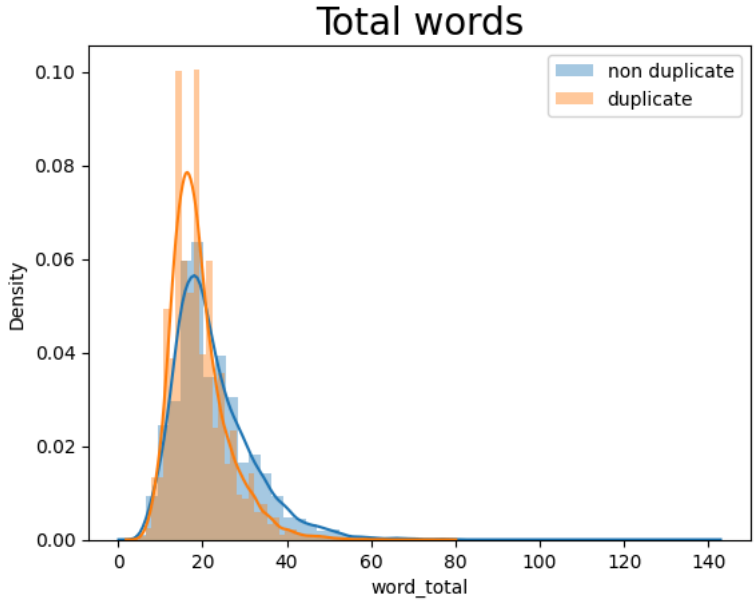


Anlysis of Common word col -

- If questions 1 and 2 have fewer than 4 common words, then the probability of those questions being non-duplicates is higher.
- If questions 1 and 2 have more than 4 common words, then the probability of those questions being duplicates is higher.

```
# 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.title("Total words" ,size = 20)
plt.legend()
plt.show()
```

```
/tmp/ipykernel_36/4263819419.py:2: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(new_df[new_df['is_duplicate'] == 0]['word_total'],label='non duplicate')
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/tmp/ipykernel_36/4263819419.py:3: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(new_df[new_df['is_duplicate'] == 1]['word_total'],label='duplicate')
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
```

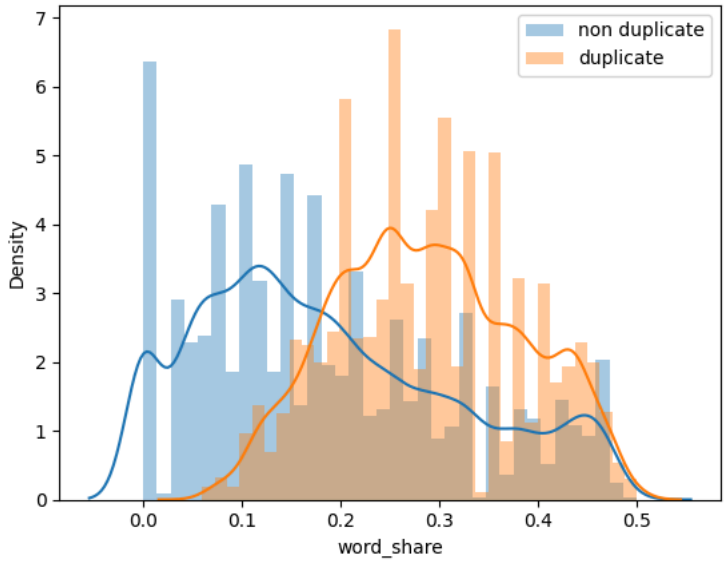


Anlysis of Total word col-

- If the total number of words is between 0 and 20, then the probability of being a duplicate is higher than being a non-duplicate.
- If the total number of words is more than 40, then the probability of being a non-duplicate is higher than being a duplicate.

```
# 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()
```

```
/tmp/ipykernel_36/542246512.py:2: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(new_df[new_df['is_duplicate'] == 0]['word_share'],label='non duplicate')
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remc
  with pd.option_context('mode.use_inf_as_na', True):
/tmp/ipykernel_36/542246512.py:3: UserWarning:

`distplot` is a deprecated function and will be removed in seaborn v0.14.0.

Please adapt your code to use either `displot` (a figure-level function with
similar flexibility) or `histplot` (an axes-level function for histograms).

For a guide to updating your code to use the new functions, please see
https://gist.github.com/mwaskom/de44147ed2974457ad6372750bbe5751

  sns.distplot(new_df[new_df['is_duplicate'] == 1]['word_share'],label='duplicate')
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remc
  with pd.option_context('mode.use_inf_as_na', True):
```



Anlysis word common / word Total

- If the word share value is 0.2 or less, then the probability of being non-duplicate is higher.
- If the word share value is greater than 0.2, then the probability of being duplicate is higher.

```
ques_df = new_df[["question1" , "question2"]]
ques_df.head()
```

	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...

```
final_df = new_df.drop(columns=['id','qid1','qid2','question1','question2'])
print("Shape of final_df -" , final_df.shape)
final_df.head()
```

Shape of final_df - (30000, 8)

	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

```
from sklearn.feature_extraction.text import CountVectorizer
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)
```

```
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
```

(30000, 6000)

```
# merge temp_df with final_df
final_df = pd.concat([temp_df , final_df] , axis = 1)
print(final_df.shape)
final_df
```

(30000, 6008)

	0	1	2	3	4	5	6	7	8	9	...	2998	2999	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	wor
398782	0	0	0	0	0	0	0	0	0	0	...	0	0	1	76	77	12	12	11	
115086	0	0	0	0	0	0	0	0	0	0	...	0	0	0	49	57	12	15	7	
327711	0	0	0	0	0	0	0	0	0	0	...	0	0	0	105	120	25	17	2	
367788	0	0	0	0	0	0	0	0	0	0	...	0	0	0	59	146	12	30	0	
151235	0	0	0	0	0	0	0	0	0	0	...	0	0	0	35	50	5	9	3	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
243932	0	0	0	0	0	0	0	0	0	0	...	0	0	1	42	41	7	7	6	
91980	0	0	0	0	0	0	0	0	0	0	...	0	0	0	68	61	12	12	4	
266955	0	0	0	0	0	0	0	0	0	0	...	0	0	0	73	98	14	17	4	
71112	0	0	0	0	0	0	0	0	0	0	...	0	0	1	51	45	10	10	5	
312470	0	0	0	0	0	1	0	0	0	0	...	0	0	1	87	77	15	14	5	

30000 rows × 6008 columns

```
# This is how our final_df look like
final_df
```

	0	1	2	3	4	5	6	7	8	9	...	2998	2999	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	word_common	wor
398782	0	0	0	0	0	0	0	0	0	0	...	0	0	1	76	77	12	12	11	
115086	0	0	0	0	0	0	0	0	0	0	...	0	0	0	49	57	12	15	7	
327711	0	0	0	0	0	0	0	0	0	0	...	0	0	0	105	120	25	17	2	
367788	0	0	0	0	0	0	0	0	0	0	...	0	0	0	59	146	12	30	0	
151235	0	0	0	0	0	0	0	0	0	0	...	0	0	0	35	50	5	9	3	
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
243932	0	0	0	0	0	0	0	0	0	0	...	0	0	1	42	41	7	7	6	
91980	0	0	0	0	0	0	0	0	0	0	...	0	0	0	68	61	12	12	4	
266955	0	0	0	0	0	0	0	0	0	0	...	0	0	0	73	98	14	17	4	
71112	0	0	0	0	0	0	0	0	0	0	...	0	0	1	51	45	10	10	5	
312470	0	0	0	0	0	1	0	0	0	0	...	0	0	1	87	77	15	14	5	

30000 rows × 6008 columns

```
# splitting the data into 80% and 20% part --> 80% would be train data and 20% would be test data
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_state=1)
```

```
# RandomForest
rf = RandomForestClassifier()
rf.fit(x_train  , y_train)
y_pred = rf.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_pred , y_test))
```

```
Accuracy Score -  0.9976666666666667
```

```
# from xgboost import XGBClassifier
# xgb = XGBClassifier()
# xgb.fit(x_train,y_train)
# y_pred = xgb.predict(x_test)
# accuracy_score(y_test,y_pred)
```

BOW Preprocessing and advanced features

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 question

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

```
# cwc_min (ratio of number of common words  to the length of smallest question) = Number of common words / min(words(q1 , a2))
# cwc_max (ratio of number of common words  to the length of highest question) = Number of common words / max(words(q1 , a2))
# csc_min  = Number of common stopwords / min(stopwords(q1 , q2))
# csc_max  = Number of common stopwords / max(stopwords(q1 , q2))

# ctc_min  = Number of common tokens / min(tokens(q1 , q2))
# ctc_max  = Number of common tokens / max(tokens(q1 , q2))

# last_word_equal =
#   - Example --> Hellow how are you
#                 I am fine
#                 Last word of both senetence (you , fine) are not equal then it is 0

# first_word_equal =
#   - Example --> Hello how are you
#                 I am fine
#                 first word of both senetence (Hello , I) are not equal then it is 0

#  Length based feature
# mean length - mean of the length of 2 question
# abs_length_diff
# Longest_substring_ratio -
```

```
# Data Preprocessing
import re
from bs4 import BeautifulSoup
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
```

```
new_df["question1"] = new_df["question1"].apply(preprocess)
new_df["question2"] = new_df["question2"].apply(preprocess)
```

```
new_df.head(1)
```

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_num_words	q2_num_words	...	ctc_max	last_w
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	...	0.923076	

1 rows × 28 columns

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

```
[nltk_data] Downloading package stopwords to /usr/share/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
True
```

```
# Advanced Features
# cwc_min (ratio of number of common words  to the length of smallest question) = Number of common words / min(words(q1 , a2))
# cwc_max (ratio of number of common words  to the length of highest question) = Number of common words / max(words(q1 , a2))

# csc_min  = Number of common stopwords / min(stopwords(q1 , q2))
# csc_max  = Number of common stopwords / max(stopwords(q1 , q2))

# ctc_min  = Number of common tokens / min(tokens(q1 , q2))
# ctc_max  = Number of common tokens / max(tokens(q1 , q2))

# last_word_equal =
#   - Example --> Hellow how are you
#                 I am fine
#                 Last word of both senetence (you , fine) is not equal then it is 0

# first_word_equal =
#   - Example --> Hello how are you
#                 I am fine
#                 first word of both senetence (Hello , I) is not equal then it is 0


from nltk.corpus import stopwords
def fetch_token_features(row):

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

  safe_div = 0.00001

  stop_words = stopwords.words("english")

  token_features =[0.0]*8

  # converting 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 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
```

```
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))
```

```
# Structure of new_df
new_df.shape
```

```
(30000, 28)
```

```
!pip install Distance
```

```
Requirement already satisfied: Distance in /usr/local/lib/python3.11/dist-packages (0.1.3)
```

```
#  Length based feature
# mean length - mean of the length of 2 question
# abs_length_diff
# Longest_substring_ratio


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
```

```
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))
```

```
!pip install fuzzywuzzy
```

```
Requirement already satisfied: fuzzywuzzy in /usr/local/lib/python3.11/dist-packages (0.18.0)
```

```
# Fuzzy Features
from fuzzywuzzy import fuzz
def fetch_fuzzy_feature(row):
  q1 = row["question1"]
  q2 = row["question2"]

  fuzzy_feature = [0.0] * 4

  # fuzzy_ratio
  fuzzy_feature[0] = fuzz.QRatio(q1 , q2)

  # fuzzy_partial_ratio
  fuzzy_feature[1] = fuzz.partial_ratio(q1 , q2)

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

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

  return fuzzy_feature
```

```
fuzzy_feature = new_df.apply(fetch_fuzzy_feature , axis = 1)

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

```
new_df.shape
```

```
(30000, 28)
```

```
# Distribution of columns
sns.pairplot(new_df[['ctc_min', 'cwc_min', 'csc_min', 'is_duplicate']],hue='is_duplicate')
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
  data_subset = grouped_data.get_group(pd_key)
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
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  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
  data_subset = grouped_data.get_group(pd_key)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
<seaborn.axisgrid.PairGrid at 0x78b657885990>
```

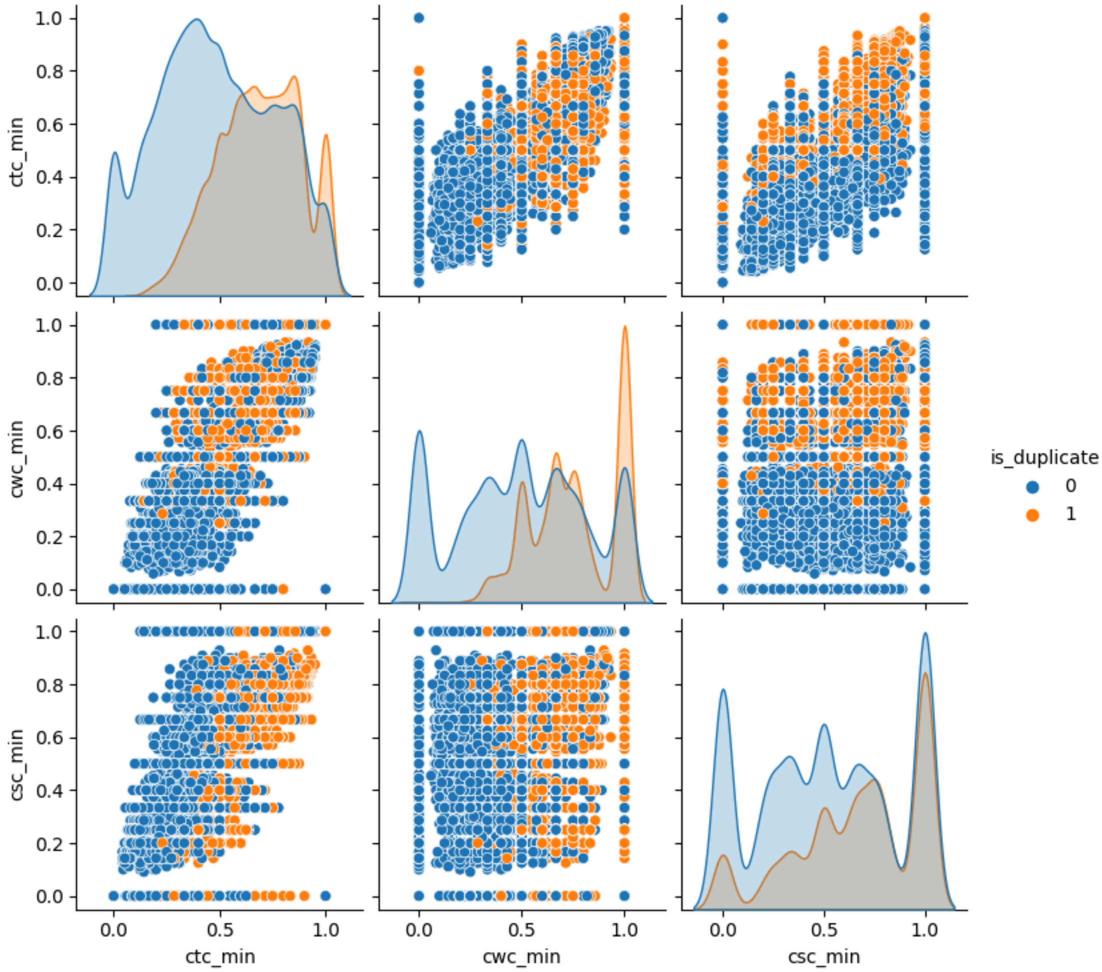


```
sns.pairplot(new_df[['ctc_max', 'cwc_max', 'csc_max', 'is_duplicate']],hue='is_duplicate')
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
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/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
  data_subset = grouped_data.get_group(pd_key)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
<seaborn.axisgrid.PairGrid at 0x78b6c7ef2390>
```

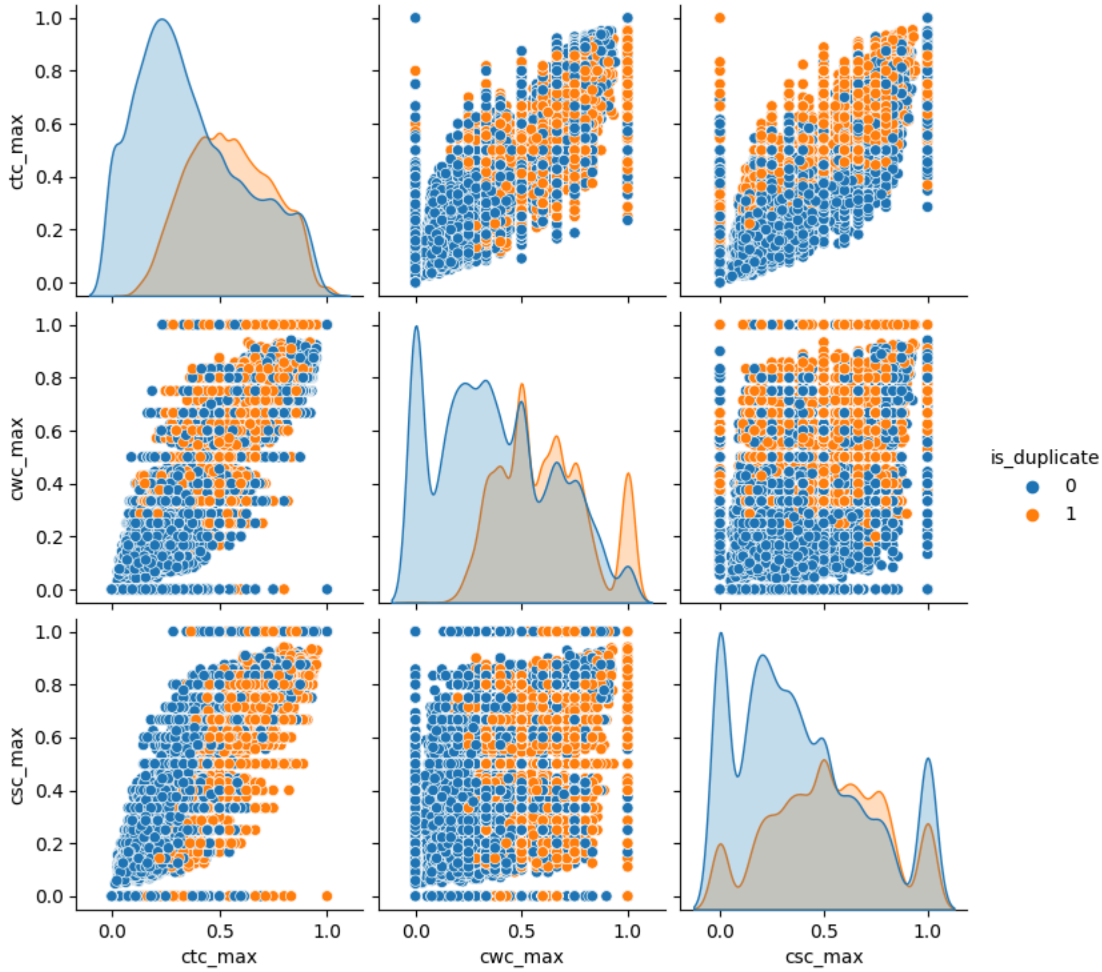


```
sns.pairplot(new_df[['last_word_eq', 'first_word_eq', 'is_duplicate']],hue='is_duplicate')
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
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/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
  data_subset = grouped_data.get_group(pd_key)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
<seaborn.axisgrid.PairGrid at 0x78b6c9f80b10>
```

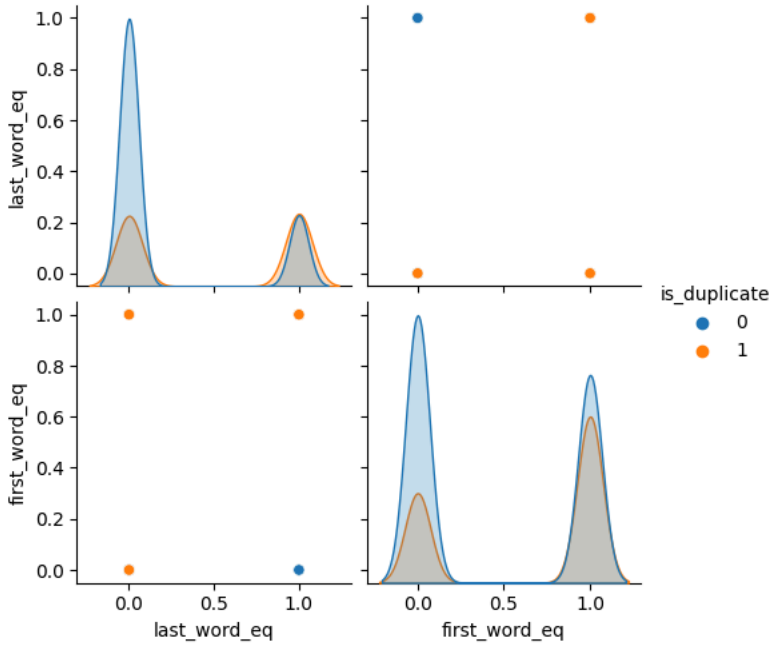


```
sns.pairplot(new_df[['mean_len', 'abs_len_diff','longest_substr_ratio', 'is_duplicate']],hue='is_duplicate')
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
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/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
  data_subset = grouped_data.get_group(pd_key)
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated and will be remo
  with pd.option_context('mode.use_inf_as_na', True):
/usr/local/lib/python3.11/dist-packages/seaborn/_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-like, you will r
  data_subset = grouped_data.get_group(pd_key)
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
<seaborn.axisgrid.PairGrid at 0x78b6d00c1590>
```
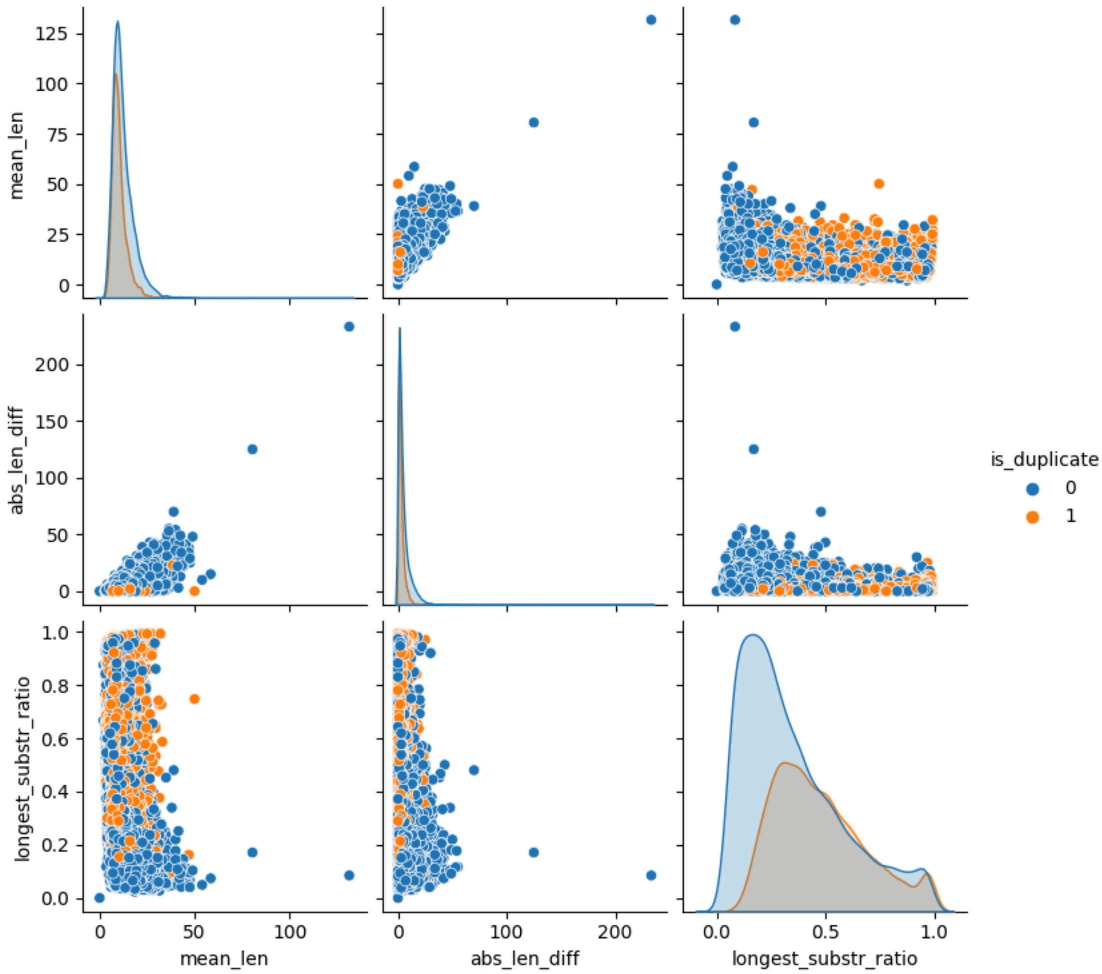




```
from sklearn.preprocessing import MinMaxScaler
x = MinMaxScaler().fit_transform(new_df[['cwc_min', 'cwc_max', 'csc_min', 'csc_max' , 'ctc_min' , 'ctc_max' , 'last_word_eq', 'first_word
y = new_df["is_duplicate"].values
```

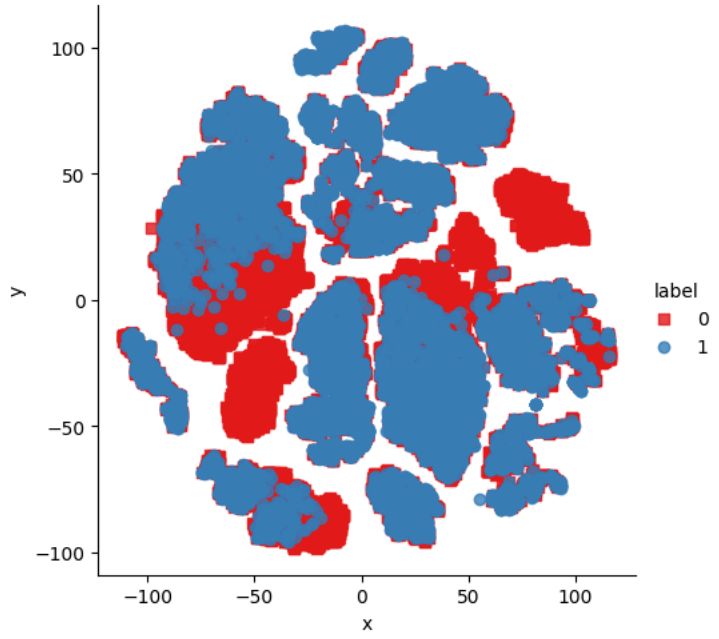
```
from sklearn.manifold import TSNE
tsne2d = TSNE(
    n_components= 2 ,
    init= "random" ,
    random_state = 101 ,
    method = "barnes_hut" ,
    n_iter = 1000 ,
    verbose = 2 ,
    angle = 0.5
).fit_transform(x)
```

```
[t-SNE] Computing 91 nearest neighbors...
[t-SNE] Indexed 30000 samples in 0.066s...
[t-SNE] Computed neighbors for 30000 samples in 5.261s...
[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: 0.080414
[t-SNE] Computed conditional probabilities in 0.842s
[t-SNE] Iteration 50: error = 110.0277405, gradient norm = 0.0225467 (50 iterations in 10.611s)
[t-SNE] Iteration 100: error = 89.8028641, gradient norm = 0.0075991 (50 iterations in 8.217s)
[t-SNE] Iteration 150: error = 85.8324585, gradient norm = 0.0048543 (50 iterations in 7.285s)
[t-SNE] Iteration 200: error = 83.9925842, gradient norm = 0.0039411 (50 iterations in 7.125s)
[t-SNE] Iteration 250: error = 82.8348312, gradient norm = 0.0028778 (50 iterations in 7.279s)
[t-SNE] KL divergence after 250 iterations with early exaggeration: 82.834831
[t-SNE] Iteration 300: error = 3.3977401, gradient norm = 0.0073746 (50 iterations in 7.114s)
[t-SNE] Iteration 350: error = 2.7806873, gradient norm = 0.0073551 (50 iterations in 6.926s)
[t-SNE] Iteration 400: error = 2.4466004, gradient norm = 0.0068728 (50 iterations in 6.813s)
[t-SNE] Iteration 450: error = 2.2383153, gradient norm = 0.0064671 (50 iterations in 6.798s)
[t-SNE] Iteration 500: error = 2.0947056, gradient norm = 0.0061190 (50 iterations in 6.793s)
[t-SNE] Iteration 550: error = 1.9898548, gradient norm = 0.0057889 (50 iterations in 6.691s)
[t-SNE] Iteration 600: error = 1.9109452, gradient norm = 0.0053841 (50 iterations in 6.798s)
[t-SNE] Iteration 650: error = 1.8499708, gradient norm = 0.0050023 (50 iterations in 6.819s)
[t-SNE] Iteration 700: error = 1.8016746, gradient norm = 0.0046590 (50 iterations in 6.741s)
[t-SNE] Iteration 750: error = 1.7624893, gradient norm = 0.0043516 (50 iterations in 6.829s)
[t-SNE] Iteration 800: error = 1.7301570, gradient norm = 0.0040461 (50 iterations in 6.843s)
[t-SNE] Iteration 850: error = 1.7029498, gradient norm = 0.0038226 (50 iterations in 6.762s)
[t-SNE] Iteration 900: error = 1.6799426, gradient norm = 0.0035596 (50 iterations in 6.740s)
[t-SNE] Iteration 950: error = 1.6603502, gradient norm = 0.0033194 (50 iterations in 6.832s)
[t-SNE] Iteration 1000: error = 1.6434221, gradient norm = 0.0031033 (50 iterations in 6.656s)
[t-SNE] KL divergence after 1000 iterations: 1.643422
```

```
x_df = pd.DataFrame({"x":tsne2d[: , 0] , "y" : tsne2d[: , 1] , "label" : y})
sns.lmplot(data=x_df, x='x', y='y', hue='label', fit_reg=False,palette="Set1",markers=['s','o'])
```

```
/usr/local/lib/python3.11/dist-packages/seaborn/axisgrid.py:118: UserWarning: The figure layout has changed to tight
  self._figure.tight_layout(*args, **kwargs)
<seaborn.axisgrid.FacetGrid at 0x78b6c86f5610>
```




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

```
#     n_iter = 1000 ,
#     verbose = 2 ,
#     angle = 0.5
# ).fit_transform(x)
```

```
# import plotly.express as px

# 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')
```

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

	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 wha...
327711	i am from india and live abroad i met a guy fr...	t i e t to thapar university to thapar univers...
367788	why do so many people in the u s hate the sout...	my boyfriend doesnt feel guilty when he hurts ...
151235	consequences of bhopal gas tragedy	what was the reason behind the bhopal gas tragedy

```
final_df = new_df.drop(columns = ["id" ,    "qid1" ,    "qid2" ,    "question1" ,   "question2"])
final_df.shape
```

```
(30000, 23)
```

```
# countvectorize
question = list(new_df["question1"]) + list(new_df["question2"])

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

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

```
(30000, 6000)
```

```
final_df = pd.concat([final_df , temp_df] , axis = 1)
final_df.shape
```

```
(30000, 6023)
```

```
# Split data into 80 20% part --? 80% would be train data and 20 % would be test data
x_train , x_test , y_train , y_test = train_test_split(final_df.iloc[: , 1:].values , final_df.iloc[: , 0].values , test_size  = .2)
```

```
rf_BOWA = RandomForestClassifier()
rf_BOWA.fit(x_train , y_train)
y_pred = rf_BOWA.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_pred , y_test))
```

```
Accuracy Score -  0.7858333333333334
```

```
XGB_BOWA = XGBClassifier()
XGB_BOWA.fit(x_train,y_train)
y_pred1 = XGB_BOWA.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_test,y_pred1))
```

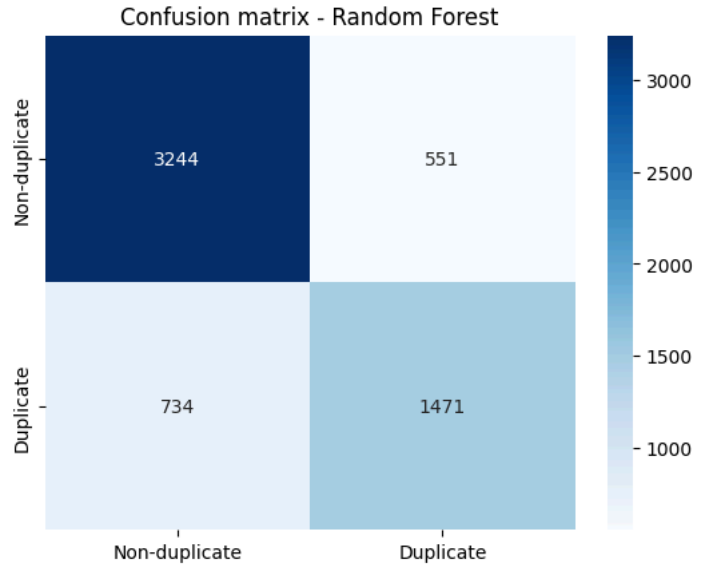
```
Accuracy Score -  0.7965
```

```
from sklearn.metrics import confusion_matrix
rf_cf = confusion_matrix(y_test,y_pred)
rf_cf
```

```
array([[3244,  551],
       [ 734, 1471]])
```

```
# Random Forest confusion matrix
# cmap=plt.cm.copper
sns.heatmap(rf_cf  , annot=True  , fmt = "d" , cmap = "Blues" , xticklabels=["Non-duplicate" , "Duplicate"] , yticklabels=["Non-duplicat
plt.title("Confusion matrix - Random Forest" , fontsize = 12)
```

```
Text(0.5, 1.0, 'Confusion matrix - Random Forest')
```



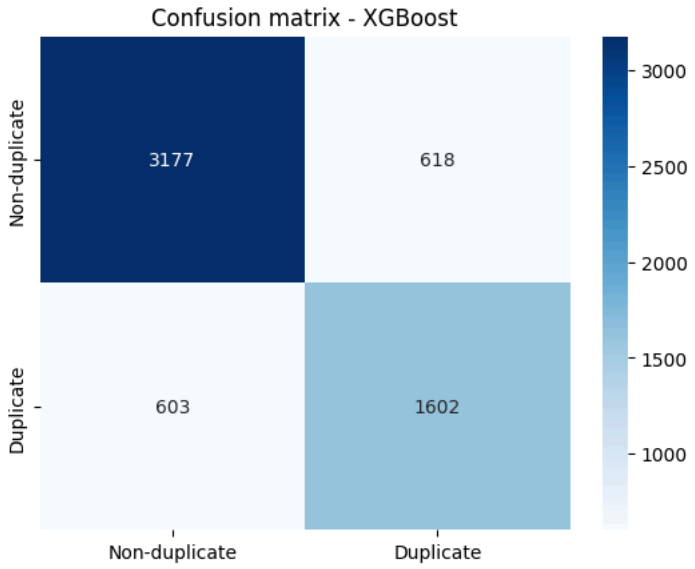
- True Negatives (3244): These are the cases where the model correctly predicted questions as not duplicates.
- False Positives (551): The model incorrectly predicted unique questions as duplicates (Type I error).
- False Negatives (734): The model missed duplicate questions and predicted them as unique (Type II error).
- True Positives (1471): The model correctly identified actual duplicates.

```
xg_cf = confusion_matrix(y_test,y_pred1)
xg_cf
```

```
array([[3177,  618],
       [ 603, 1602]])
```

```
# XGBoost confusion matrix
sns.heatmap(xg_cf  , annot=True ,fmt = "d" , cmap = "Blues" , xticklabels=["Non-duplicate" , "Duplicate"] , yticklabels=["Non-duplicate'
plt.title("Confusion matrix - XGBoost" , fontsize = 12)
```

```
Text(0.5, 1.0, 'Confusion matrix - XGBoost')
```



- True Negatives (TN): 3177 — Model correctly identified non-duplicate pairs.
- False Positives (FP): 618 — Model incorrectly Identify unique questions as duplicates (Type I error).
- False Negatives (FN): 603 — Model missed some duplicate pairs, marking them as unique (Type II error). We likely more to be focus on FN beacause if questions are `duplicate` but my model label that questions as `Non-duplicate` then it would be cost for me
- True Positives (TP): 1602 — Model correctly predicted duplicate question pairs.
- As compare to our previous Random forest model XGBoost lower FN means it detects duplicates more reliably than Random Forest in our case.

```
from sklearn.tree import DecisionTreeClassifier
dt_BOWA = DecisionTreeClassifier(
    criterion = "gini" ,
    max_depth = 99 ,
    max_features  = "sqrt" ,

)
dt_BOWA.fit(x_train , y_train)
```

```
DecisionTreeClassifier(max_depth=99, max_features='sqrt')
```

```
y_pred = dt_BOWA.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_pred , y_test))
```

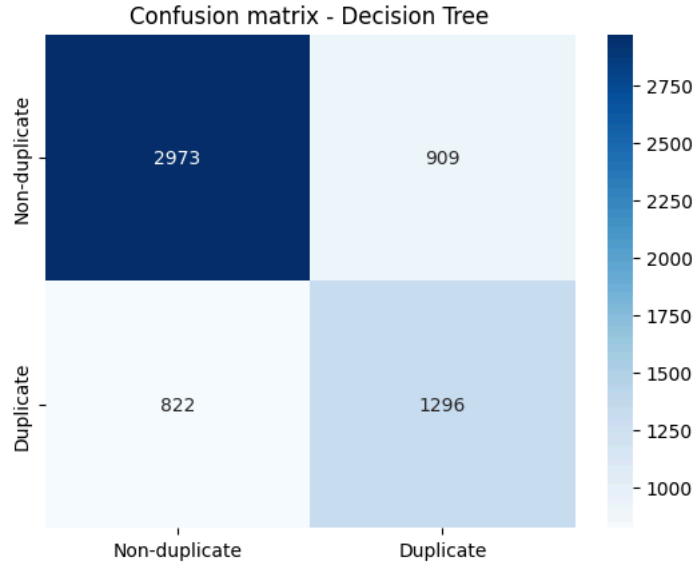
```
Accuracy Score -  0.7115
```

```
dt_cf  = confusion_matrix(y_pred , y_test)
dt_cf
```

```
array([[2973,  909],
       [ 822, 1296]])
```

```
sns.heatmap(dt_cf , annot = True ,fmt = "d" ,xticklabels=("Non-duplicate" , "Duplicate") , yticklabels=("Non-duplicate", "Duplicate") ,
plt.title("Confusion matrix - Decision Tree")
```

```
Text(0.5, 1.0, 'Confusion matrix - Decision Tree')
```




```
# Logistic Regression
from sklearn.linear_model import LogisticRegression
LR = LogisticRegression()
LR.fit(x_train , y_train)
```

```
/usr/local/lib/python3.11/dist-packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed to converge (status=
STOP: TOTAL NO. OF ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

▾ LogisticRegression

LogisticRegression()

```
y_pred = LR.predict(x_test)
print("Accuracy Score - " , accuracy_score(y_pred , y_test))
```

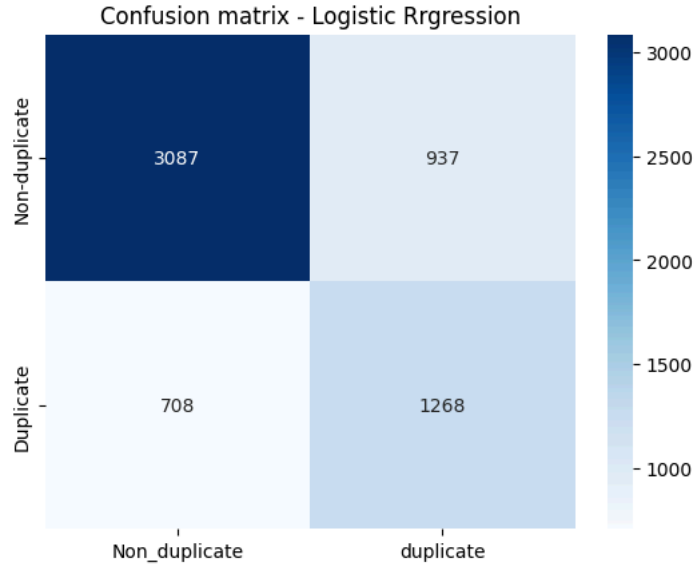
```
Accuracy Score -  0.7258333333333333
```

```
lr_cf = confusion_matrix(y_pred , y_test)
lr_cf
```

```
array([[3087,  937],
       [ 708, 1268]])
```

```
sns.heatmap(lr_cf , annot = True , fmt = "d"  , cmap = "Blues", xticklabels=("Non_duplicate" , "duplicate") , yticklabels=("Non-duplicat
plt.title("Confusion matrix - Logistic Rrgression")
```

```
Text(0.5, 1.0, 'Confusion matrix - Logistic Rrgression')
```



```
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)

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))

def test_fetch_token_features(q1 , q2):

  safe_div = 0.0001

  stop_words = stopwords.words("english")

  token_features = [0.0] * 8

  # conveeting the sent into tokens
  q1_token = q1.split()
  q2_token = q2.split()

  if len(q1_token) == 0 or len(q2_token) == 0:
    return token_features


  # get the non-stopwords in question
  q1_words = set([word for word in q1_token if word not in stop_words])
  q2_words = set([word for word in q2_token if word not in stop_words])

  # get the stopwords in question
  q1_stops = set([word for word in q1_token if word in stop_words])
  q2_stops = set([word for word in q2_token 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_token).intersection(set(q2_token)))


  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_token), len(q2_token)) + safe_div)
  token_features[5] = common_token_count / (max(len(q2_token), len(q2_token)) + safe_div)

  # Last word of both question is same or not
  token_features[6] = int(q1_token[-1] == q2_token[-1])

  # First word of both question is same or not
  token_features[7] = int(q1_token[0] == q2_token[0])

  return token_features
```

```
def test_fetch_length_fearture(q1 , q2):

  length_features = [0.0]*3

  # converting the sent 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 feature
  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)
```