NLP Project on Quora Duplicate Questions Pair Identification

Problem Statement and Objective

In the online world, people tend to ask the same questions in various ways, especially on platforms like Quora. This creates confusion for readers and makes it challenging for businesses to provide consistent answers. The goal of this article is to explore how NLP (Natural Language Processing) and machine learning can be used to develop a system that identifies and responds to similar queries. Businesses are seeking a solution to save time and effort by automating the process of recognizing and answering similar questions across different expressions.

Dataset Description

The dataset chosen for this NLP project is from a renowned Kaggle competition hosted by Quora, offering a prize of $25,000. The dataset consists of five columns, featuring two columns with distinct questions, two columns containing the corresponding question IDs, and a final column indicating the target variable. The target variable is binary, with a value of 1 denoting duplicate questions and 0 indicating non-duplicate ones.

link: https://www.kaggle.com/c/quora-question-pairs/data?select=train.csv.zip

Project Development Overflow

Basic Data Analysis ---> Feature Engineering ---> Model Development ---> Optimize the model to increase performance

Basic Data Analysis

1.Load the Dataset

In [1]:

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

import warnings
warnings.filterwarnings('ignore')

df = pd.read_csv('questions.csv')
df.shape
```

Out[1]:

```
(404351, 6)
```

In [2]:

```
# the dataset is too large for our RAM. So we take a sample dataset
df_pos = df[df['is_duplicate']==1]
df_neg = df[df['is_duplicate']==0]
df = pd.concat([df_pos[:7500], df_neg[:7500]], axis=0)
df.head()
```

Out[2]:

	id	qid1	qid2	question1	question2	is_duplicate
5	5	11	12	Astrology: I am a Capricorn Sun Cap moon and	I'm a triple Capricorn (Sun, Moon and	1

	id	qid1	qid2	c... question1	ascendan... question2	is_duplicate
7	7	15	16	How can I be a good geologist?	What should I do to be a great geologist?	1
11	11	23	24	How do I read and find my YouTube comments?	How can I see all my Youtube comments?	1
12	12	25	26	What can make Physics easy to learn?	How can you make physics easy to learn?	1
13	13	27	28	What was your first sexual experience like?	What was your first sexual experience?	1

In [3]:

```
import pandas as pd

def text_processing_quora_separate(data):
    from bs4 import BeautifulSoup
    import re
    from nltk.corpus import stopwords
    from tqdm import tqdm
    from nltk.stem import PorterStemmer

    def decontracted(phrase):
        # specific
        phrase = re.sub(r'<br /><br />', ' ', phrase)
        phrase = re.sub(r"won't", "will not", phrase)
        phrase = re.sub(r"can\'t", "can not", phrase)

        # general
        phrase = re.sub(r"n\'t", " not", phrase)
        phrase = re.sub(r"\'re", " are", phrase)
        phrase = re.sub(r"\'s", " is", phrase)
        phrase = re.sub(r"\'d", " would", phrase)
        phrase = re.sub(r"\'ll", " will", phrase)
        phrase = re.sub(r"\'t", " not", phrase)
        phrase = re.sub(r"\'ve", " have", phrase)
        phrase = re.sub(r"\'m", " am", phrase)
        phrase = re.sub(r'"', " ", phrase)
        return phrase

    stopwords_set = set(stopwords.words("english"))

    preprocessed_question1 = []
    preprocessed_question2 = []
    porter = PorterStemmer()

    # tqdm is for printing the status bar
    for row in tqdm(data.itertuples(), total=len(data), desc="Processing Quora Data"):
        q1 = row.question1
        q2 = row.question2

        # Process question1
        processed_q1 = re.sub(r"http\S+", "", q1)
        processed_q1 = decontracted(processed_q1)
        processed_q1 = re.sub("\S*\d\S*", "", processed_q1).strip()
        processed_q1 = ' '.join(word.lower() for word in processed_q1.split() if word no
t in stopwords_set)
        stemmed_words_q1 = [porter.stem(word) for word in processed_q1.split()]
        preprocessed_question1.append(' '.join(stemmed_words_q1))

        # Process question2
        processed_q2 = re.sub(r"http\S+", "", q2)
        processed_q2 = decontracted(processed_q2)
        processed_q2 = re.sub("\S*\d\S*", "", processed_q2).strip()
        processed_q2 = ' '.join(word.lower() for word in processed_q2.split() if word no
t in stopwords_set)
        stemmed_words_q2 = [porter.stem(word) for word in processed_q2.split()]
        preprocessed_question2.append(' '.join(stemmed_words_q2))

    return preprocessed_question1, preprocessed_question2
```

```
# Preprocess the questions separately
preprocessed_q1, preprocessed_q2 = text_processing_quora_separate(df)

# Replace the original columns with the preprocessed versions
df['question1'] = preprocessed_q1
df['question2'] = preprocessed_q2

df.head()
```

```
Processing Quora Data: 100%|██████████████████████████████████████████████████| 15000/15
000 [00:05<00:00, 2556.75it/s]
```

Out[3]:

	id	qid1	qid2	question1	question2	is_duplicate
5	**5**	**11**	**12**	**astrology: i capricorn sun cap moon cap rising...**	**i tripl capricorn (sun, moon ascend capricorn)...**	**1**
7	**7**	**15**	**16**	**how i good geologist?**	**what i great geologist?**	**1**
11	**11**	**23**	**24**	**how i read find youtub comments?**	**how i see youtub comments?**	**1**
12	**12**	**25**	**26**	**what make physic easi learn?**	**how make physic easi learn?**	**1**
13	**13**	**27**	**28**	**what first sexual experi like?**	**what first sexual experience?**	**1**

2.Check for Null Values

In [4]:

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

Out[4]:

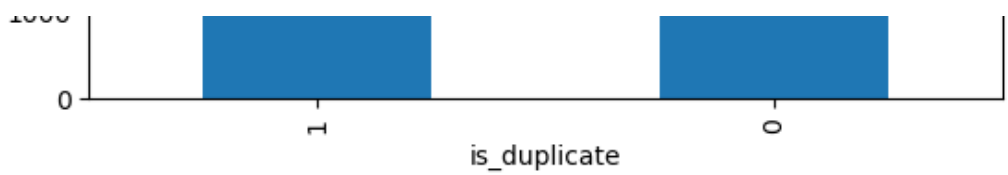
```
id              0
qid1            0
qid2            0
question1       0
question2       0
is_duplicate    0
dtype: int64
```

so there are no null values in the dataset

3.Check Duplicates Distribution

In [5]:

```
df['is_duplicate'].value_counts().plot(kind='bar');
```

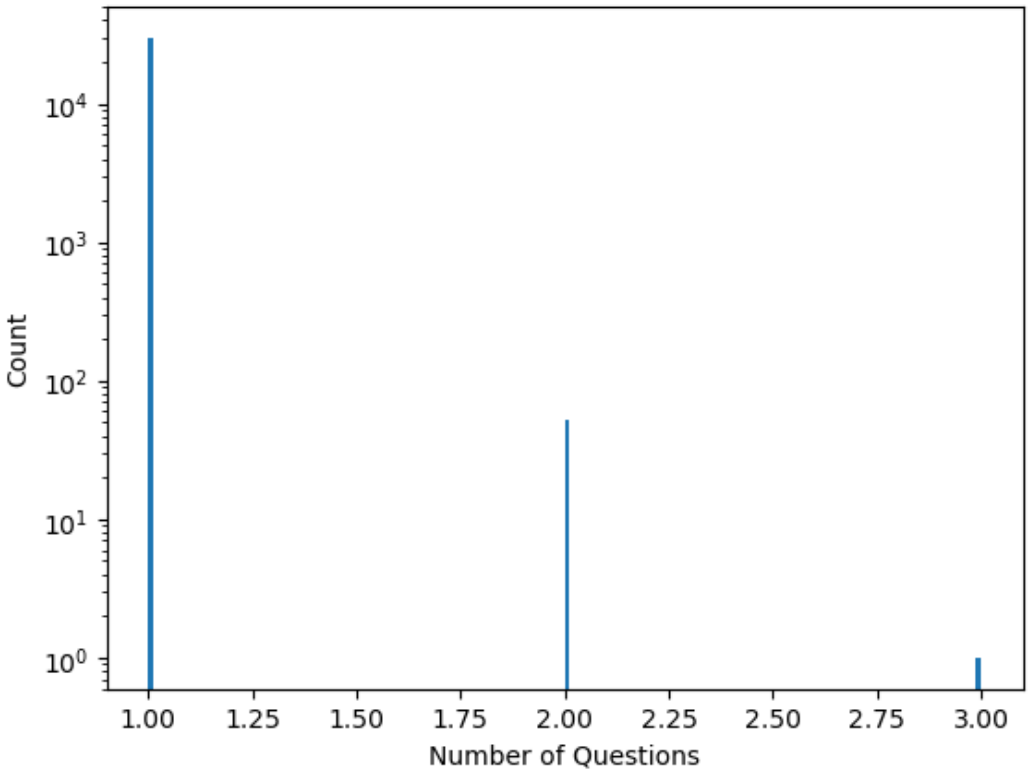


4.Check for Repeated Questions

In [6]:

```
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])
plt.hist(qid.value_counts().values,bins=160)
plt.yscale('log')
plt.xlabel('Number of Questions')
plt.ylabel('Count')
plt.show()
```

```
Number of unique questions 29946
Number of questions getting repeated 53
```



Feature Engineering

Feature engineering is a fundamental technique that involves adding new features to a dataset, aiming to enhance the prediction of output variables and improve model accuracy. Crucial features have a direct impact on the model's performance. Feature engineering encompasses various processes such as transformation, scaling, feature extraction, feature encoding, and exploratory data analysis (EDA).

In our case, we plan to augment our existing dataset by introducing seven additional features. Leveraging the bag of words model for questions 1 and 2, we will generate distinct features. These newly created features will undergo exploratory data analysis before being incorporated into the machine learning model, contributing to a more robust predictive framework.

1. Question Length

In [7]:

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

2. Number of Words

In [8]:

```
df['q1_word_count'] = df['question1'].str.split().str.len()
df['q2_word_count'] = df['question2'].str.split().str.len()
df.head()
```

Out[8]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count
5	5	11	12	astrology: i capricorn sun cap moon cap rising...	i tripl capricorn (sun, moon ascend capricorn)...	1	61	59	10	10
7	7	15	16	how i good geologist?	what i great geologist?	1	21	23	4	4
11	11	23	24	how i read find youtub comments?	how i see youtub comments?	1	32	26	6	5
12	12	25	26	what make physic easi learn?	how make physic easi learn?	1	28	27	5	5
13	13	27	28	what first sexual experi like?	what first sexual experience?	1	30	29	5	4

3. Common Word Count

In [9]:

```
def common_word_count(x):
    q1_words = set(map(lambda word: word.lower().strip(), x['question1'].split(" ")))
    q2_words = set(map(lambda word: word.lower().strip(), x['question2'].split(" ")))

    return len(q1_words & q2_words)
df['common_word_count'] = df.apply(common_word_count, axis=1)
df.head()
```

Out[9]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count	common_word_cou
5	5	11	12	astrology: i capricorn sun cap moon cap rising...	i tripl capricorn (sun, moon ascend capricorn)...	1	61	59	10	10	
7	7	15	16	how i good geologist?	what i great geologist?	1	21	23	4	4	
11	11	23	24	how i read find youtub comments?	how i see youtub comments?	1	32	26	6	5	
12	12	25	26	what make physic easi learn?	how make physic easi learn?	1	28	27	5	5	
13	13	27	28	what first sexual experi like?	what first sexual experience?	1	30	29	5	4	

4. Total Words

In [10]:

In [10]:

```
def calculate_total_words(row):
    words_set_q1 = set(map(lambda word: word.lower().strip(), row['question1'].split(" "
)))
    words_set_q2 = set(map(lambda word: word.lower().strip(), row['question2'].split(" "
)))

    total_words = len(words_set_q1) + len(words_set_q2)

    return total_words

df['word_total'] = df.apply(calculate_total_words, axis=1)
df.head()
```

Out[10]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count	common_word_cou
5	5	11	12	astrology: i capricorn sun cap moon cap rising...	i tripl capricorn (sun, moon ascend capricorn)...	1	61	59	10	10	
7	7	15	16	how i good geologist?	what i great geologist?	1	21	23	4	4	
11	11	23	24	how i read find youtub comments?	how i see youtub comments?	1	32	26	6	5	
12	12	25	26	what make physic easi learn?	how make physic easi learn?	1	28	27	5	5	
13	13	27	28	what first sexual experi like?	what first sexual experience?	1	30	29	5	4	

5. Words Shared

In [11]:

```
df['word_shared'] = round(df['common_word_count']/df['word_total'], 2)
df.head()
```

Out[11]:

	id	qid1	qid2	question1	question2	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count	common_word_cou
5	5	11	12	astrology: i capricorn sun cap moon cap rising...	i tripl capricorn (sun, moon ascend capricorn)...	1	61	59	10	10	
7	7	15	16	how i good geologist?	what i great geologist?	1	21	23	4	4	
11	11	23	24	how i read find youtub comments?	how i see youtub comments?	1	32	26	6	5	
12	12	25	26	what make physic easi learn?	how make physic easi learn?	1	28	27	5	5	
13	13	27	28	what first sexual experi like?	what first sexual experience?	1	30	29	5	4	

Exploratory Data Analysis for Newly Added Features

In [12]:

```
# Analyze the relationship between the features
```

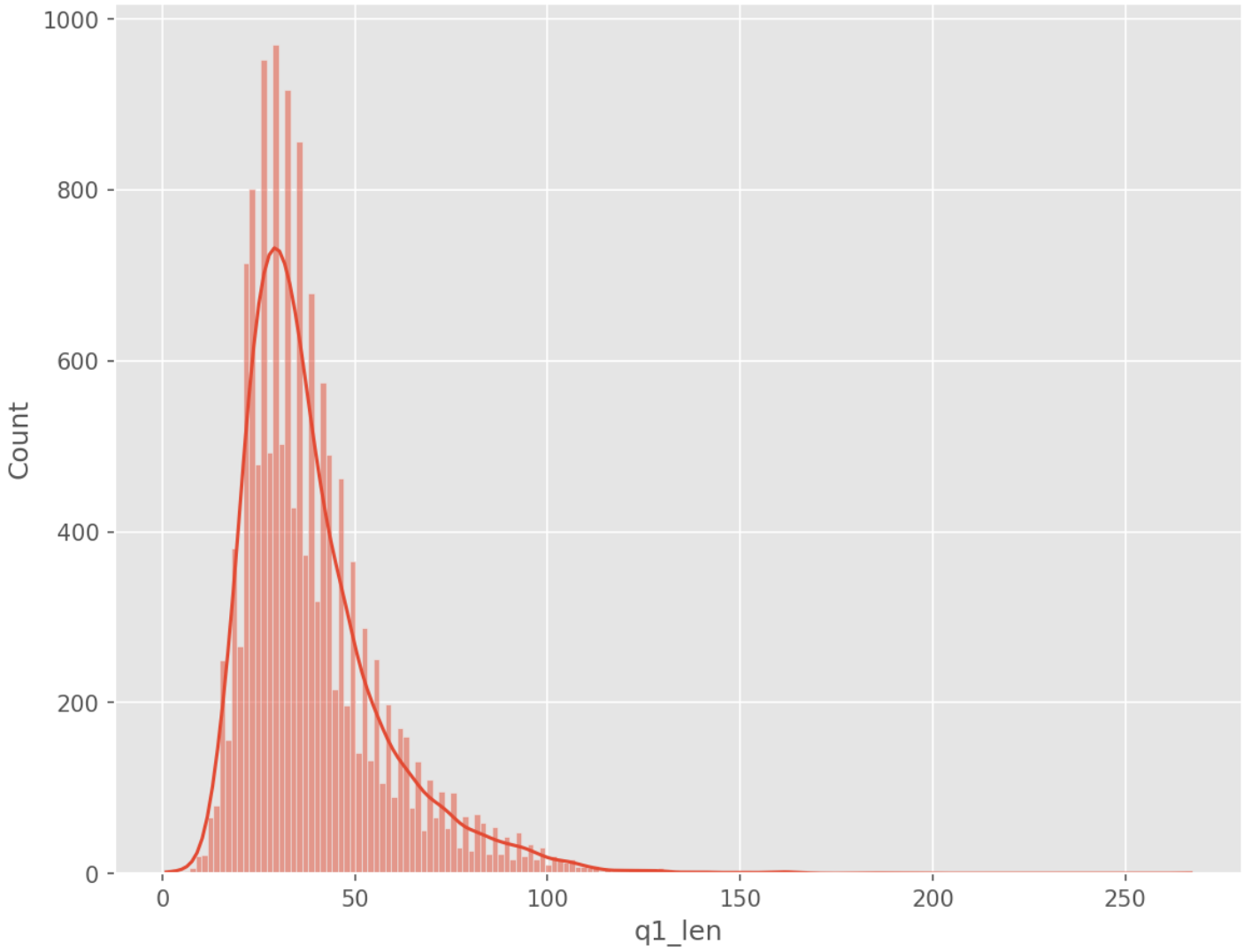
1. Distribution of Questions

In [13]:

```
print('q1: _____________________')
print('\t\t\tminimum characters',df['q1_len'].min())
print('\t\t\tmaximum characters',df['q1_len'].max())
print('\t\t\taverage num of characters',int(df['q1_len'].mean()))
plt.style.use("ggplot")

plt.figure(figsize=(9, 7), dpi=150)
sns.histplot(df['q1_len'], kde=True)
plt.show()
```

```
q1: _____________________
   minimum characters 1
   maximum characters 267
   average num of characters 39
```

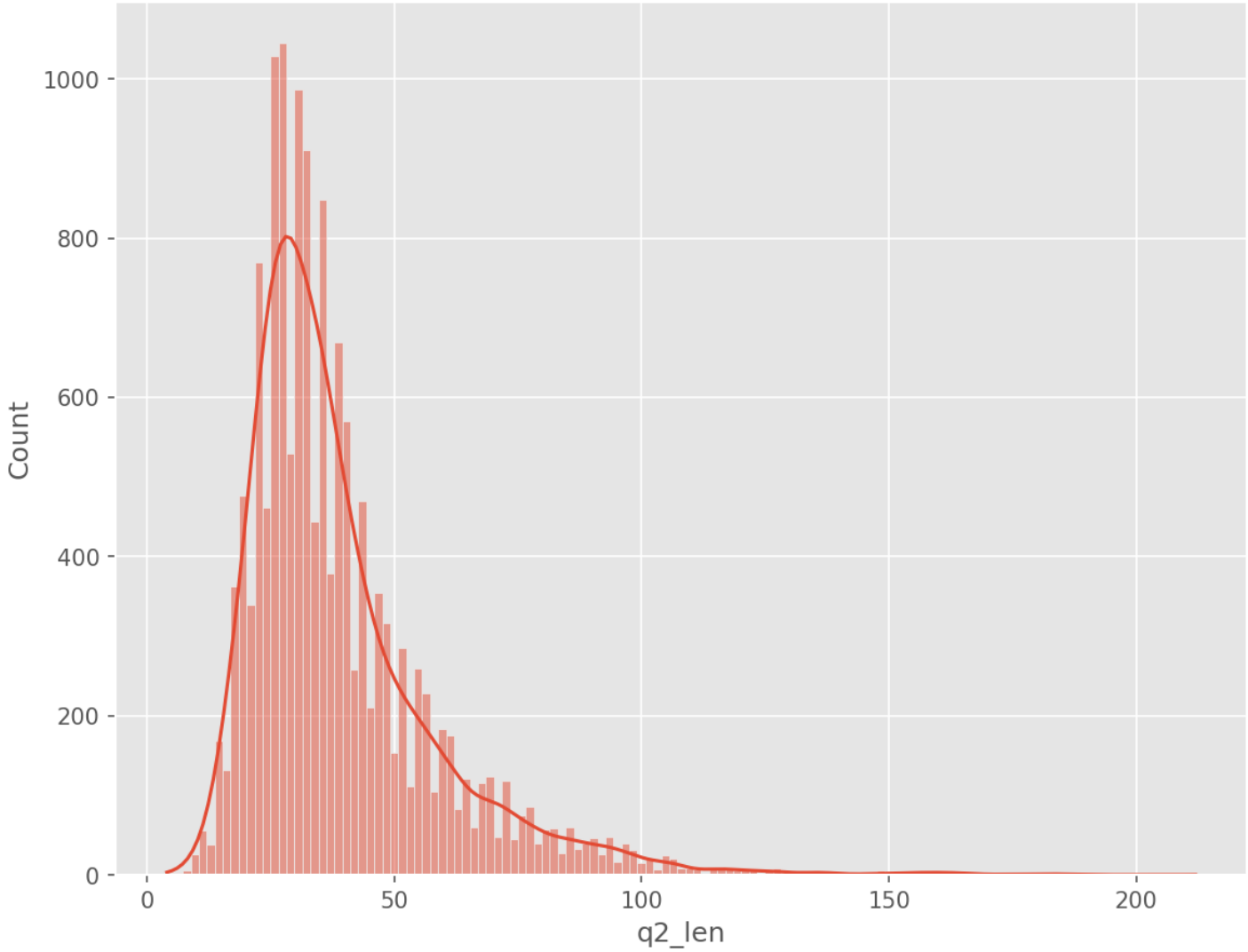


In [14]:

```
print('q2:_____________________')
print('\t\t\tminimum characters',df['q2_len'].min())
print('\t\t\tmaximum characters',df['q2_len'].max())
print('\t\t\taverage num of characters',int(df['q2_len'].mean()))
plt.style.use("ggplot")
```

```
plt.figure(figsize=(9, 7), dpi=150)
sns.histplot(df[df['q2_len']<600]['q2_len'], kde=True)
plt.show()
```

```
q2:_____________________
   minimum characters 4
   maximum characters 699
   average num of characters 39
```

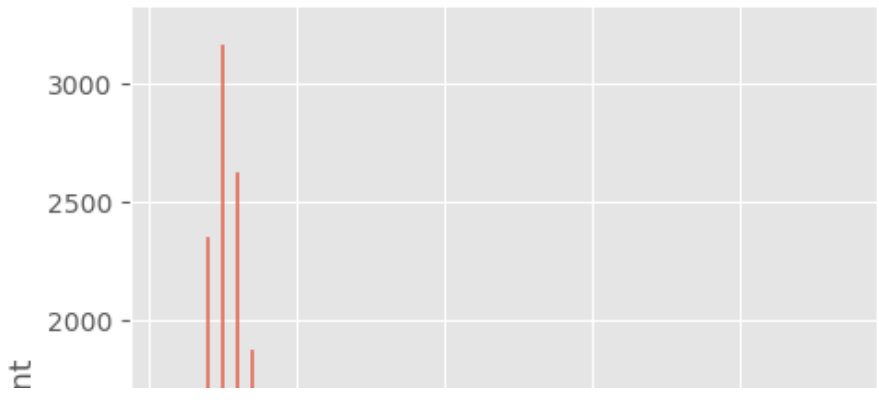


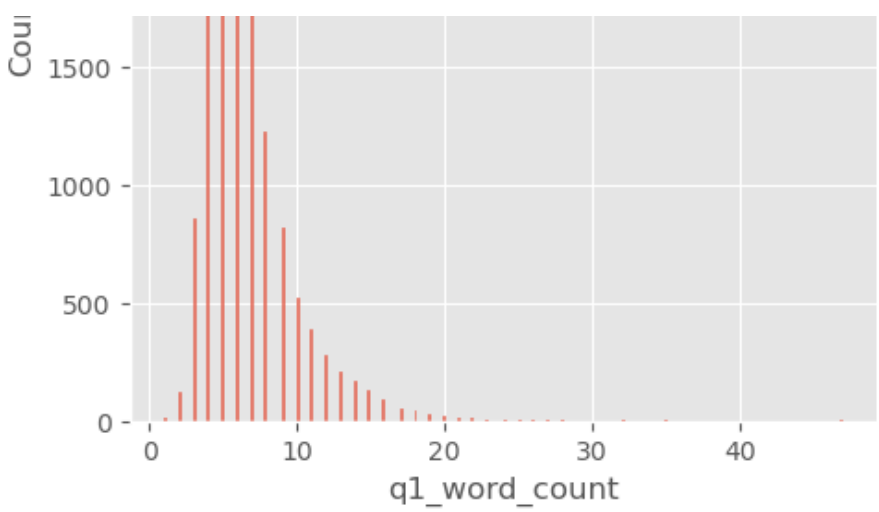
2. Distribution of the Number of Words

In [15]:

```
sns.displot(df['q1_word_count'])
print('minimum words',df['q1_word_count'].min())
print('maximum words',df['q1_word_count'].max())
print('average num of words',int(df['q1_word_count'].mean()))
```

```
minimum words 1
maximum words 47
average num of words 6
```

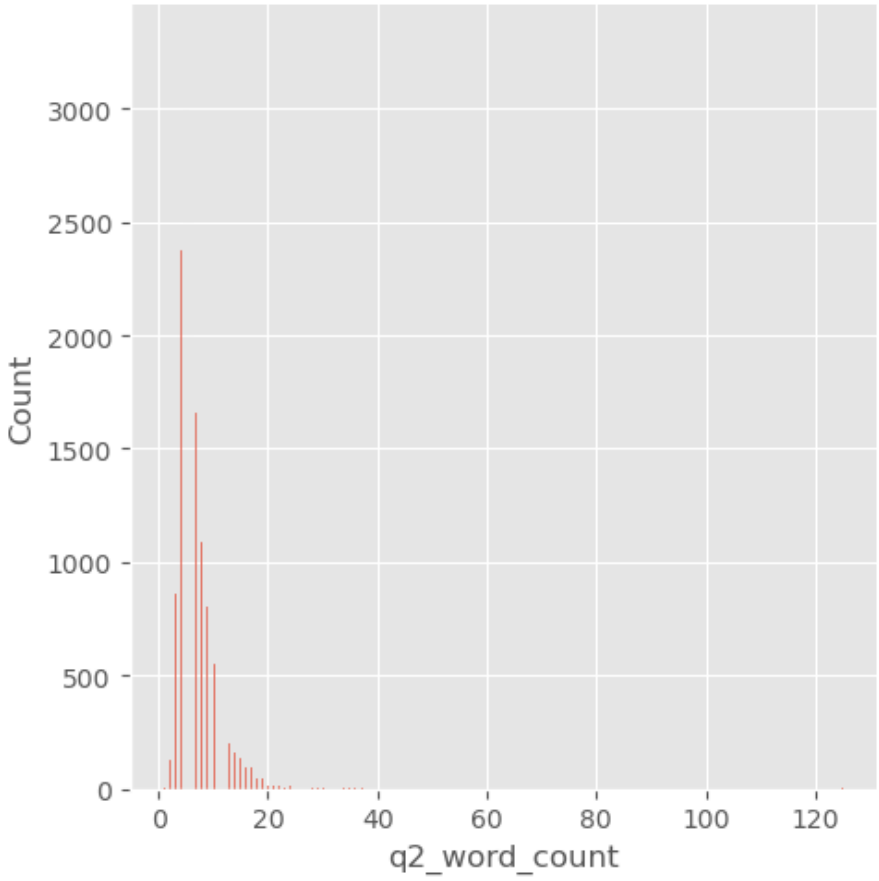




In [16]:

```
sns.displot(df[df['q2_word_count']<200]['q2_word_count'])
print('minimum words',df['q2_word_count'].min())
print('maximum words',df['q2_word_count'].max())
print('average num of words',int(df['q2_word_count'].mean()))
```

```
minimum words 1
maximum words 125
average num of words 6
```



3. Common Word Distribution

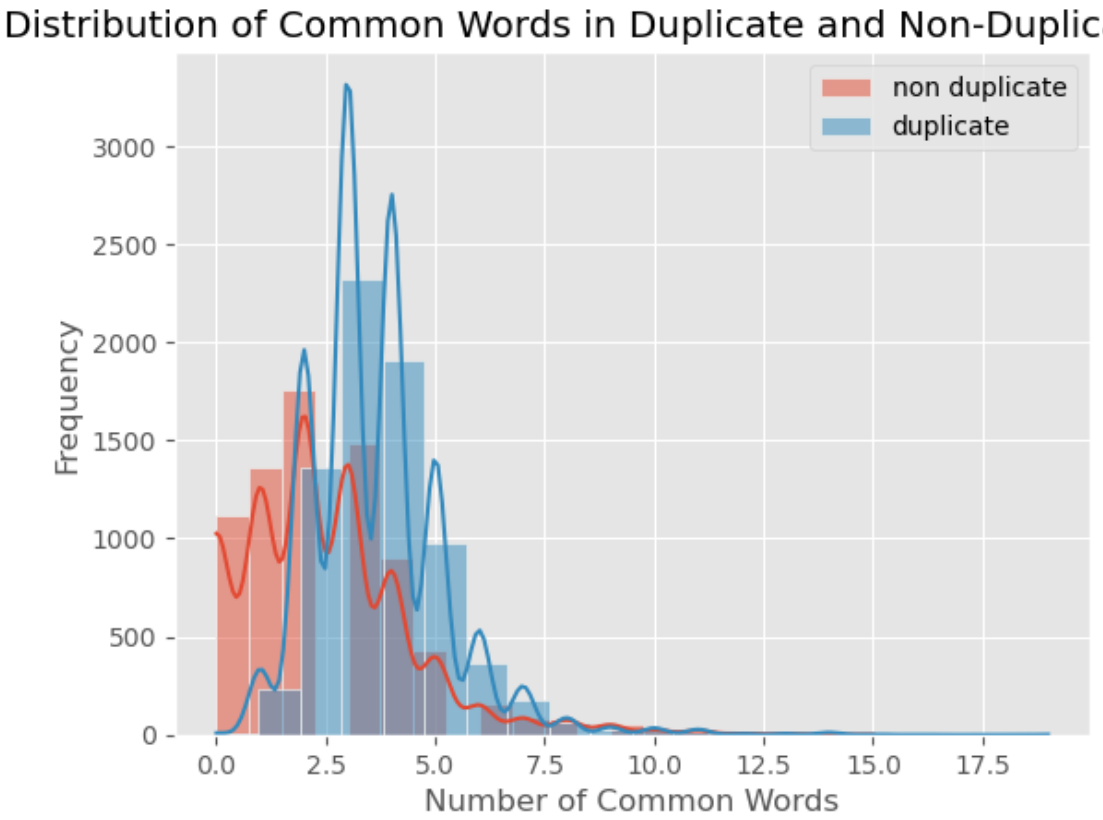
In [17]:

```
sns.histplot(df[df['is_duplicate'] == 0]['common_word_count'], label='non duplicate', kd
e=True, bins=20)
sns.histplot(df[df['is_duplicate'] == 1]['common_word_count'], label='duplicate', kde=Tr
ue, bins=20)

plt.xlabel('Number of Common Words')
plt.ylabel('Frequency')
plt.title('Distribution of Common Words in Duplicate and Non-Duplicate Pairs')
```

```
plt.legend()

plt.show()
```



From the graph, we see that the probability that it will be a duplicate question is more if the number of common words exceeds 4

4. Total Word Analysis

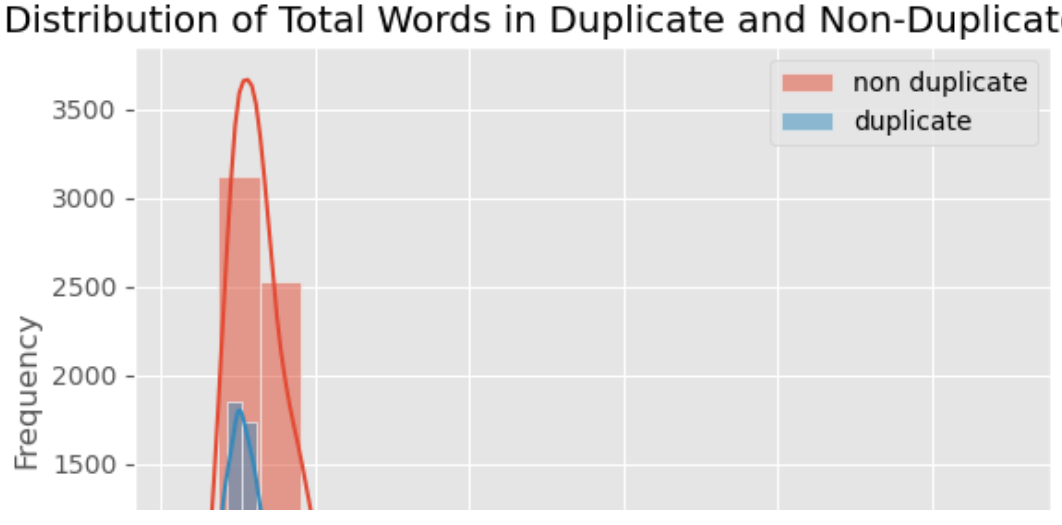
In [18]:

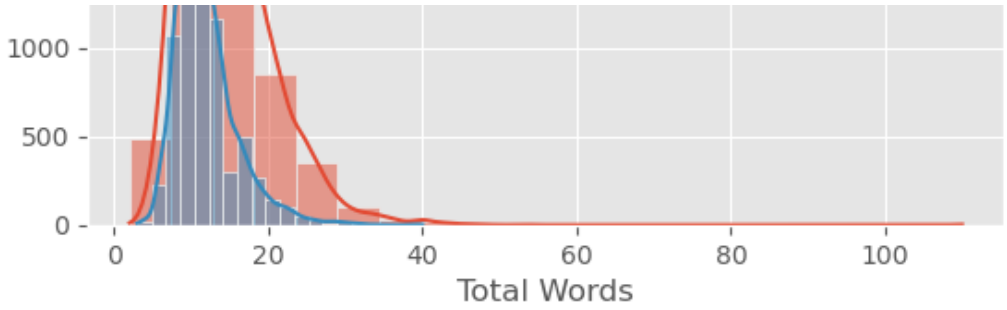
```
sns.histplot(df[df['is_duplicate'] == 0]['word_total'], label='non duplicate', kde=True,
bins=20)
sns.histplot(df[df['is_duplicate'] == 1]['word_total'], label='duplicate', kde=True, bin
s=20)

plt.xlabel('Total Words')
plt.ylabel('Frequency')
plt.title('Distribution of Total Words in Duplicate and Non-Duplicate Pairs')

plt.legend()

plt.show()
```





Records are duplicated when the word count is between 0 and 20. For counts exceeding 40, the model strongly prioritizes non-duplicates.

5. Word Shared Analysis

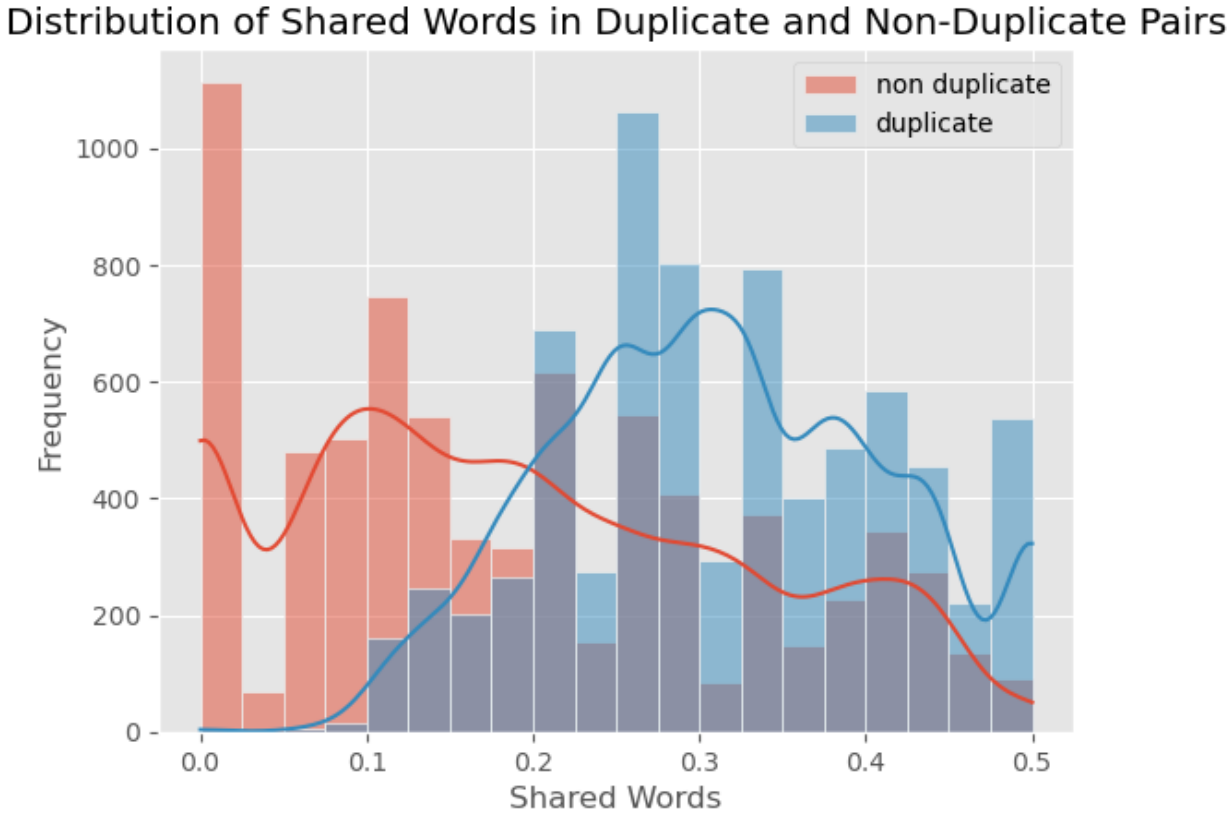
In [19]:

```
sns.histplot(df[df['is_duplicate'] == 0]['word_shared'], label='non duplicate', kde=True
, bins=20)
sns.histplot(df[df['is_duplicate'] == 1]['word_shared'], label='duplicate', kde=True, bi
ns=20)

plt.xlabel('Shared Words')
plt.ylabel('Frequency')
plt.title('Distribution of Shared Words in Duplicate and Non-Duplicate Pairs')

plt.legend()

plt.show()
```



Non-duplicates are probable when the words' share value is below 0.2. However, duplication is expected if the word's share value surpasses 0.2.

Machine Learning Model

1. Separate the Independent and Dependent features

In [20]:

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

Out[20]:

	question1	question2
5	astrology: i capricorn sun cap moon cap rising...	i tripl capricorn (sun, moon ascend capricorn)...
7	how i good geologist?	what i great geologist?
11	how i read find youtub comments?	how i see youtub comments?
12	what make physic easi learn?	how make physic easi learn?
13	what first sexual experi like?	what first sexual experience?

In [21]:

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

```
(15000, 8)
```

Out[21]:

	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count	common_word_count	word_total	word_shared
5	1	61	59	10	10	5	19	0.26
7	1	21	23	4	4	2	8	0.25
11	1	32	26	6	5	4	11	0.36
12	1	28	27	5	5	4	10	0.40
13	1	30	29	5	4	3	9	0.33

2. Vectorizing the Feature

In [22]:

```
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)

temp1=pd.DataFrame(q1_arr,index=ques_df.index)
temp2=pd.DataFrame(q2_arr,index=ques_df.index)

temp=pd.concat([temp1,temp2],axis=1)

temp.head()
```

Out[22]:

	0	1	2	3	4	5	6	7	8	9	...	2990	2991	2992	2993	2994	2995	2996	2997	2998	2999
5	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	1	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	...	0	0	0	0	0	0	0	0	0	0

5 rows × 6000 columns

In [23]:

```
from sklearn.preprocessing import MinMaxScaler
features_to_scale = final_df.columns[1:]
scaler = MinMaxScaler()
final_df[features_to_scale] = scaler.fit_transform(final_df[features_to_scale])
final_df.head()
```

Out[23]:

	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count	common_word_count	word_total	word_shared
5	1	0.225564	0.079137	0.195652	0.072581	0.263158	0.157407	0.52
7	1	0.075188	0.027338	0.065217	0.024194	0.105263	0.055556	0.50
11	1	0.116541	0.031655	0.108696	0.032258	0.210526	0.083333	0.72
12	1	0.101504	0.033094	0.086957	0.032258	0.210526	0.074074	0.80
13	1	0.109023	0.035971	0.086957	0.024194	0.157895	0.064815	0.66

In [24]:

```
final_df=pd.concat([final_df,temp],axis=1)
print(final_df.shape)
final_df.head()
```

```
(15000, 6008)
```

Out[24]:

	is_duplicate	q1_len	q2_len	q1_word_count	q2_word_count	common_word_count	word_total	word_shared	0	1	...
5	1	0.225564	0.079137	0.195652	0.072581	0.263158	0.157407	0.52	0	0	...
7	1	0.075188	0.027338	0.065217	0.024194	0.105263	0.055556	0.50	0	0	...
11	1	0.116541	0.031655	0.108696	0.032258	0.210526	0.083333	0.72	0	0	...
12	1	0.101504	0.033094	0.086957	0.032258	0.210526	0.074074	0.80	0	0	...
13	1	0.109023	0.035971	0.086957	0.024194	0.157895	0.064815	0.66	0	0	...

5 rows × 6008 columns

3. Train-Test-Split

In [25]:

```
X = final_df.iloc[:,1:].values
y = final_df.iloc[:,0].values
```

In [26]:

```
from sklearn.model_selection import train_test_split
X_train,X_test,y_train,y_test = train_test_split(X,
                                                 y,
                                                 test_size=0.2,
                                                 random_state=1)
```

In [27]:

```
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score
clf = RandomForestClassifier()
clf.fit(X_train,y_train)

y_pred_train = clf.predict(X_train)
y_pred_test = clf.predict(X_test)
```

In [28]:

```
print(accuracy_score(y_train, y_pred_train))
print(accuracy_score(y_test,y_pred_test))
```

```
0.9996666666666667
0.776
```

OVERFITTING !!!!

In [29]:

```
# from sklearn.model_selection import GridSearchCV
# param_grid = {
#     'n_estimators': [50, 100, 200],
#     'max_depth': [None, 10, 20],
#     'min_samples_leaf': [1, 2, 4],
# }

# grid_search = GridSearchCV(estimator=RandomForestClassifier(), param_grid=param_grid, s
coring='accuracy')
# grid_search.fit(X_train, y_train)
# best_params = grid_search.best_params_
# best_clf = grid_search.best_estimator_
# print("Best Parameters:", best_params)
# y_pred_test_tuned = best_clf.predict(X_test)
# accuracy_tuned = accuracy_score(y_test, y_pred_test_tuned)
# print("Accuracy after tuning:", accuracy_tuned)
```

In [30]:

```
from xgboost import XGBClassifier
xgb = XGBClassifier()
xgb.fit(X_train,y_train)
y_pred_train = xgb.predict(X_train)
y_pred_test = xgb.predict(X_test)
```

In [31]:

```
print(accuracy_score(y_train, y_pred_train))
print(accuracy_score(y_test,y_pred_test))
```

```
0.8251666666666667
0.7673333333333333
```

In [32]:

```
from sklearn.tree import DecisionTreeClassifier
from sklearn.metrics import accuracy_score

dtc = DecisionTreeClassifier()
dtc.fit(X_train, y_train)
y_pred_train = dtc.predict(X_train)
y_pred_test = dtc.predict(X_test)
```

In [33]:

```
print(accuracy_score(y_pred_train, y_train))
print(accuracy_score(y_pred_test, y_test))
```

```
0.9996666666666667
0.7173333333333334
```

In [34]:

```
from sklearn.ensemble import AdaBoostClassifier

abc = AdaBoostClassifier()
abc.fit(X_train, y_train)
```

```
y_pred_train = abc.predict(X_train)
y_pred_test = abc.predict(X_test)
```

In [35]:

```
print(accuracy_score(y_pred_train, y_train))
print(accuracy_score(y_pred_test, y_test))
```

```
0.7466666666666667
0.7316666666666667
```

In [ ]:

```

```