```
import numpy as np
import pandas as pd
```

```
# Importing Dataset
reviews = pd.read_excel('hotel_reviews.xlsx')
reviews.head(5)
```

	Review	Rating
0	nice hotel expensive parking got good deal sta...	4
1	ok nothing special charge diamond member hilto...	2
2	nice rooms not 4* experience hotel monaco seat...	3
3	unique, great stay, wonderful time hotel monac...	5
4	great stay great stay, went seahawk game aweso...	5

```
reviews.shape
```

```
(20491, 2)
```

```
reviews.Rating.describe()
```

```
count    20491.000000
mean         3.952223
std          1.233030
min          1.000000
25%          3.000000
50%          4.000000
75%          5.000000
max          5.000000
Name: Rating, dtype: float64
```

```
reviews.columns
```

```
Index(['Review', 'Rating'], dtype='object')
```

```
reviews['Rating'].unique()
```

```
array([4, 2, 3, 5, 1])
```

```
count =reviews.isnull().sum().sort_values(ascending=False)
count
```

```
Review    0
Rating    0
dtype: int64
```

```
reviews_f=reviews.copy()
```

```
#Number of Words
reviews_f['word_count'] = reviews_f['Review'].apply(lambda x: len(str(x).split(" ")))
reviews_f[['Review','word_count']].head()
```

	Review	word_count
0	nice hotel expensive parking got good deal sta...	89
1	ok nothing special charge diamond member hilto...	252
2	nice rooms not 4* experience hotel monaco seat...	219
3	unique, great stay, wonderful time hotel monac...	91
4	great stay great stay, went seahawk game aweso...	193

```
#Number of characters including space
reviews_f['char_count'] = reviews_f['Review'].str.len()
reviews_f[['Review','char_count']].head()
```

	Review	char_count
0	nice hotel expensive parking got good deal sta...	593
1	ok nothing special charge diamond member hilto...	1689
2	nice rooms not 4* experience hotel monaco seat...	1427
3	unique, great stay, wonderful time hotel monac...	600
4	great stay great stay, went seahawk game aweso...	1281

```
#Average Word Length
def avg_word(sentence):
  words = str(sentence).split()
  return (sum(len(word) for word in words)/len(words))

reviews_f['avg_word'] = reviews_f['Review'].apply(lambda x: avg_word(x))
reviews_f[['Review','avg_word']].head()
```

	Review	avg_word
0	nice hotel expensive parking got good deal sta...	5.804598
1	ok nothing special charge diamond member hilto...	5.752000
2	nice rooms not 4* experience hotel monaco seat...	5.571429
3	unique, great stay, wonderful time hotel monac...	5.730337
4	great stay great stay, went seahawk game aweso...	5.701571

```
#Number of stopwords
!pip install nltk
import nltk
from nltk.corpus import stopwords
nltk.download('stopwords')
stop = stopwords.words('english')

reviews_f['stopwords'] = reviews_f['Review'].apply(lambda x: len([x for x in str(x).split() if x in stop]))
reviews_f[['Review','stopwords']].head()
```

```
Requirement already satisfied: nltk in /usr/local/lib/python3.10/dist-packages (3.8.
Requirement already satisfied: click in /usr/local/lib/python3.10/dist-packages (fro
Requirement already satisfied: joblib in /usr/local/lib/python3.10/dist-packages (fr
Requirement already satisfied: regex>=2021.8.3 in /usr/local/lib/python3.10/dist-pac
Requirement already satisfied: tqdm in /usr/local/lib/python3.10/dist-packages (from
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

	Review	stopwords
0	nice hotel expensive parking got good deal sta...	6
1	ok nothing special charge diamond member hilto...	12
2	nice rooms not 4* experience hotel monaco seat...	5
3	unique, great stay, wonderful time hotel monac...	3
4	great stay great stay, went seahawk game aweso...	11

```
#Number of special characters
import re
special_characters = "!@#$%^&*()-_+={}[]:;\"'<>,./\?|~`"

# Function to count words starting with special characters
def count_special_words(review):
    words = re.findall(r'\b[' + re.escape(special_characters) + r']\w*\b', str(review))
    return len(words)

# Apply the function to the 'Review' column
reviews_f['hashtags'] = reviews_f['Review'].apply(count_special_words)

# Display the 'Review' and 'hashtags' columns
reviews_f[['Review', 'hashtags']].head()
```

	Review	hashtags
0	nice hotel expensive parking got good deal sta...	1
1	ok nothing special charge diamond member hilto...	6
2	nice rooms not 4* experience hotel monaco seat...	13
3	unique, great stay, wonderful time hotel monac...	3
4	great stay great stay, went seahawk game aweso...	6

```
#Number of numerics
reviews_f['numerics'] = reviews_f['Review'].apply(lambda x: len([x for x in str(x).split() if x.isdigit()]))
reviews_f[['Review','numerics']].head()
```

	Review	numerics
0	nice hotel expensive parking got good deal sta...	1
1	ok nothing special charge diamond member hilto...	6
2	nice rooms not 4* experience hotel monaco seat...	7
3	unique, great stay, wonderful time hotel monac...	1
4	great stay great stay, went seahawk game aweso...	2

```
#Number of Uppercase words
reviews_f['upper'] = reviews_f['Review'].apply(lambda x: len([x for x in str(x).split() if x.isupper()]))
reviews_f[['Review','upper']].head()
```

	Review	upper
0	nice hotel expensive parking got good deal sta...	0
1	ok nothing special charge diamond member hilto...	0
2	nice rooms not 4* experience hotel monaco seat...	0
3	unique, great stay, wonderful time hotel monac...	0
4	great stay great stay, went seahawk game aweso...	0

```
reviews_f.columns
```

```
Index(['Review', 'Rating', 'word_count', 'char_count', 'avg_word', 'stopwords',
       'hashtags', 'numerics', 'upper'],
      dtype='object')
```

```
reviews_f.head()
```

	Review	Rating	word_count	char_count	avg_word	stopwords	hashtags	numerics
0	nice hotel expensive parking got good deal sta...	4	89	593	5.804598	6	1	1
	ok nothing special charge							

```
reviews_f.describe()
```

	Rating	word_count	char_count	avg_word	stopwords	hashtag
count	20491.000000	20491.000000	20491.000000	20491.000000	20491.000000	20491.00000
mean	3.952223	106.375043	725.245571	5.999689	3.572788	3.99082
std	1.233030	100.655267	689.933070	0.443135	4.661568	5.31218
min	1.000000	9.000000	44.000000	4.038462	0.000000	0.00000
25%	3.000000	50.000000	339.000000	5.704882	1.000000	1.00000
50%	4.000000	79.000000	537.000000	5.974522	2.000000	2.00000
75%	5.000000	126.000000	859.000000	6.264706	5.000000	5.00000
max	5.000000	1933.000000	13501.000000	8.666667	85.000000	108.00000

```
reviews_f
```

	Review	Rating	word_count	char_count	avg_word	stopwords	hashtags	numer
0	nice hotel expensive parking got good deal sta...	4	89	593	5.804598	6	1	
1	ok nothing special charge diamond member hilto...	2	252	1689	5.752000	12	6	
2	nice rooms not 4* experience hotel monaco seat...	3	219	1427	5.571429	5	13	
	unique, great stay							

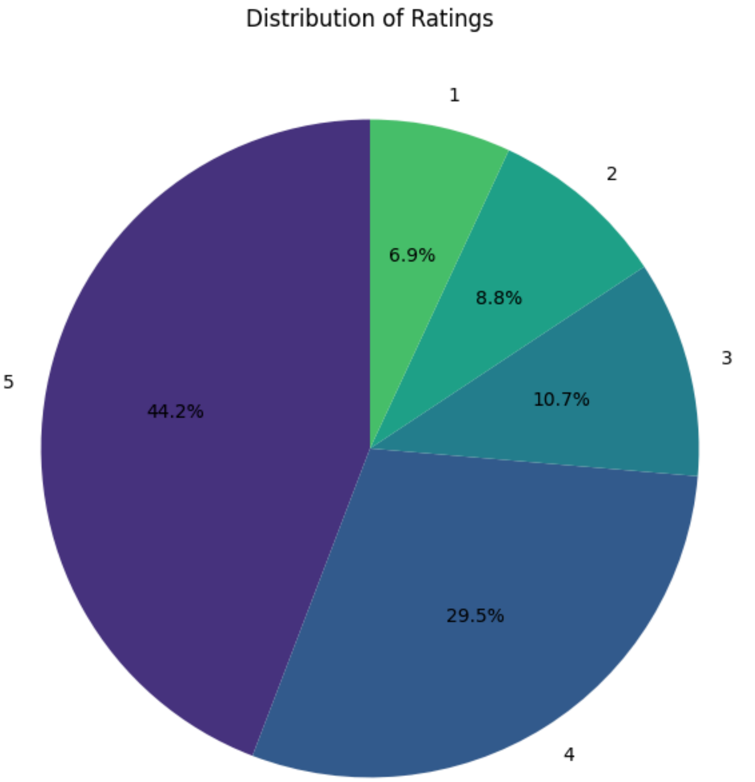
```
#reviews_f['hashtags'].sum()
data=reviews_f.copy()
data1=data.drop(['Rating','Review'],axis=1)
data1.head()
```

	word_count	char_count	avg_word	stopwords	hashtags	numerics	upper
0	89	593	5.804598	6	1	1	0
1	252	1689	5.752000	12	6	6	0
2	219	1427	5.571429	5	13	7	0
3	91	600	5.730337	3	3	1	0
4	193	1281	5.701571	11	6	2	0

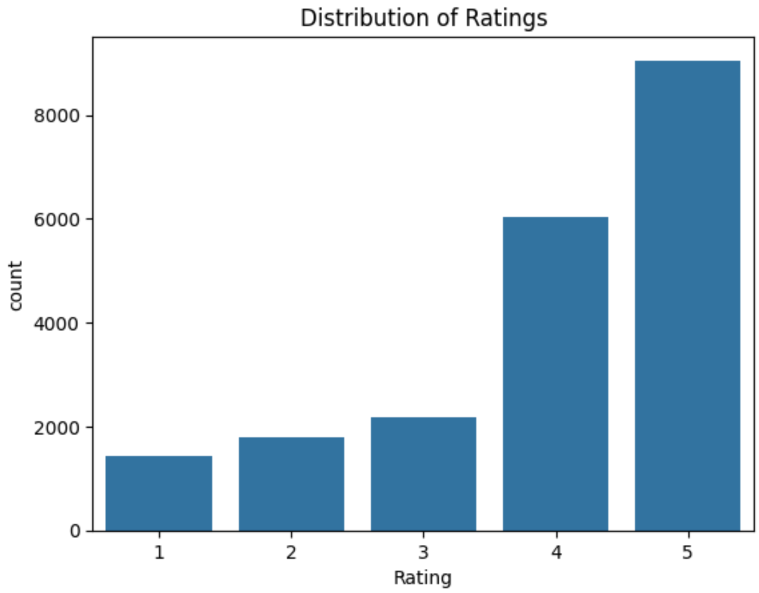
```
print("Total Stopwords present =", data1['stopwords'].sum())
print("Total hashtags present =",  data1['hashtags'].sum())
print("Total Numbers present =",   data1['numerics'].sum())
print("Total Uppercase present =",   data1['upper'].sum())
```

```
Total Stopwords present = 73210
Total hashtags present = 81776
Total Numbers present = 38610
Total Uppercase present = 22
```

```
#Exploring the distribution of ratings:
import seaborn as sns
import matplotlib.pyplot as plt

# Plotting the distribution of ratings using a pie chart
rating_counts = reviews['Rating'].value_counts()

plt.figure(figsize=(8, 8))
plt.pie(rating_counts, labels=rating_counts.index, autopct='%1.1f%%', startangle=90, colors=sns.color_palette('viridis')
plt.title('Distribution of Ratings')
plt.show()
```



```
# Ploting the distribution of ratings
sns.countplot(x='Rating', data=reviews)
plt.title('Distribution of Ratings')
plt.show()
```



Text Cleaning

```
reviews
```

	Review	Rating
0	nice hotel expensive parking got good deal sta...	4
1	ok nothing special charge diamond member hilto...	2
2	nice rooms not 4* experience hotel monaco seat...	3
3	unique, great stay, wonderful time hotel monac...	5
4	great stay great stay, went seahawk game aweso...	5
...	...	...
20486	best kept secret 3rd time staying charm, not 5...	5
20487	great location price view hotel great quick pl...	4
20488	ok just looks nice modern outside, desk staff ...	2
20489	hotel theft ruined vacation hotel opened sept ...	1
20490	people talking, ca n't believe excellent ratin...	2

20491 rows × 2 columns

```
reviews_df = reviews.sample(frac = 0.5, replace = False, random_state=42)
```

```
reviews_df
```

	Review	Rating
10726	not recommend hotel did reviewers actually sta...	1
14919	barcelona rocks, stayed hotel jazz girlfriend ...	4
19098	ok hotel good location stayed night way beijin...	3
2450	great service nice pool ok beach lovely ground...	4
960	surprising treat spent weekend july 15/16 2006...	5
...	...	...
16444	great hotel husband spent week-end month park ...	4
6633	great holidays, lovely holidays better expecte...	4
16825	amazing views stayed 3 adults 4 nights great t...	5
15931	excellent hotel beach standard westin nusa dua...	4
15331	return stayed raffles 5 nights beginning price...	4

10246 rows × 2 columns

```
# remove 'No Negative' or 'No Positive' from text
reviews_df["Review"] = reviews_df["Review"].apply(lambda x: x.replace("No Negative", "").replace("No Positive", ""))
```

This can be useful when analyzing sentiment or text data where these phrases may not provide meaningful information.

Part-Of-Speech (POS) tagging: assign a tag to every word to define if it corresponds to a noun, a verb etc. using the WordNet lexical database

```
import string

from nltk import pos_tag
from nltk.corpus import stopwords
from nltk.tokenize import WhitespaceTokenizer
from nltk.stem import WordNetLemmatizer
from nltk.corpus import wordnet
```

```
!python -m nltk.downloader averaged_perceptron_tagger
```

```
/usr/lib/python3.10/runpy.py:126: RuntimeWarning: 'nltk.downloader' found in sys.modules after import of package 'nltk', but prior
  warn(RuntimeWarning(msg))
[nltk_data] Downloading package averaged_perceptron_tagger to
[nltk_data]     /root/nltk_data...
[nltk_data]   Unzipping taggers/averaged_perceptron_tagger.zip.
```

```
nltk.download('wordnet')
```

```
[nltk_data] Downloading package wordnet to /root/nltk_data...
True
```

```
# return the wordnet object value corresponding to the POS tag

def get_wordnet_pos(pos_tag):
    if pos_tag.startswith('J'):
        return wordnet.ADJ
    elif pos_tag.startswith('V'):
        return wordnet.VERB
    elif pos_tag.startswith('N'):
        return wordnet.NOUN
    elif pos_tag.startswith('R'):
        return wordnet.ADV
    else:
        return wordnet.NOUN
```

```
def clean_text(text):
    text = text.lower()                                                 # lower text
    text = [word.strip(string.punctuation) for word in text.split(" ")]  # tokenize text and remove puncutation
    text = [word for word in text if not any(c.isdigit() for c in word)] # remove words that contain numbers
    stop = stopwords.words('english')
    stop = stopwords.words('english')
    text = [x for x in text if x not in stop]                                   # remove stop words
    text = [t for t in text if len(t) > 0]                                      # remove empty tokens
    pos_tags = pos_tag(text)                                                    # pos tag text
    text = [WordNetLemmatizer().lemmatize(t[0],
            get_wordnet_pos(t[1])) for t in pos_tags]                           # lemmatize text
    text = [t for t in text if len(t) > 1]                                      # remove words with only one letter
    text = " ".join(text) # join all
    return(text)

# clean text data
reviews_df["Review_clean"] = reviews_df["Review"].apply(lambda x: clean_text(x))
```

```
reviews_df
```

	Review	Rating	Review_clean
10726	not recommend hotel did reviewers actually sta...	1	recommend hotel reviewer actually stay hotel g...
14919	barcelona rocks, stayed hotel jazz girlfriend ...	4	barcelona rock stay hotel jazz girlfriend nigh...
19098	ok hotel good location stayed night way beijin...	3	ok hotel good location stay night way beijing ...
2450	great service nice pool ok beach lovely ground...	4	great service nice pool ok beach lovely ground...
960	surprising treat spent weekend july 15/16 2006...	5	surprising treat spend weekend july cartwright...
...	...	...	...
16444	great hotel husband spent week-end month park ...	4	great hotel husband spend week-end month park ...
6633	great holidays, lovely holidays better expecte...	4	great holiday lovely holiday well expect readi...

Sentiment Analysis

```
nltk.download('vader_lexicon')
```

```
[nltk_data] Downloading package vader_lexicon to /root/nltk_data...
True
```

```
# add sentiment anaylsis columns
from nltk.sentiment.vader import SentimentIntensityAnalyzer

sid = SentimentIntensityAnalyzer()
reviews_df["Sentiments"] = reviews_df["Review_clean"].apply(lambda x: sid.polarity_scores(x))
reviews_df = pd.concat([reviews_df.drop(['Sentiments'], axis=1), reviews_df['Sentiments'].apply(pd.Series)], axis=1)
```

```
reviews_df
```

	Review	Rating	Review_clean	neg	neu	pos	compound
10726	not recommend hotel did reviewers actually sta...	1	recommend hotel reviewer actually stay hotel g...	0.223	0.490	0.286	0.5367
14919	barcelona rocks, stayed hotel jazz girlfriend ...	4	barcelona rock stay hotel jazz girlfriend nigh...	0.129	0.686	0.185	0.9648
19098	ok hotel good location stayed night way beijin...	3	ok hotel good location stay night way beijing ...	0.000	0.572	0.428	0.9217
2450	great service nice pool ok beach lovely ground...	4	great service nice pool ok beach lovely ground...	0.057	0.631	0.313	0.9982
960	surprising treat spent weekend july 15/16 2006...	5	surprising treat spend weekend july cartwright...	0.043	0.644	0.313	0.9816
...	...	...	...	...	...	...	...
16444	great hotel husband spent week-end month park ...	4	great hotel husband spend week-end month park ...	0.018	0.562	0.419	0.9806
6633	great holidays, lovely holidays better expecte...	4	great holiday lovely holiday well expect readi...	0.045	0.623	0.333	0.9994
16825	amazing views stayed 3 adults 4 nights great t...	5	amaze view stay adult night great time bedroom...	0.041	0.450	0.509	0.9916
15931	excellent hotel beach standard westin nusa dua...	4	excellent hotel beach standard westin nusa dua...	0.048	0.608	0.345	0.9846
15331	return stayed raffles 5 nights beginning price...	4	return stay raffle night begin price get room ...	0.106	0.518	0.377	0.9398

10246 rows × 7 columns

```
reviews_df.describe()
```

	Rating	neg	neu	pos	compound
count	10246.000000	10246.000000	10246.000000	10246.000000	10246.000000
mean	3.949541	0.063107	0.604523	0.332372	0.852566
std	1.233141	0.061664	0.103579	0.123313	0.378342
min	1.000000	0.000000	0.201000	0.000000	-0.990900
25%	3.000000	0.019000	0.541000	0.249250	0.937100
50%	4.000000	0.050000	0.611000	0.328000	0.977400
75%	5.000000	0.090000	0.673000	0.409000	0.990000
max	5.000000	0.673000	1.000000	0.799000	0.999900

```
def classify_sentiment(compound_score):
    if compound_score > 0.5:
        return 'Positive'
    elif compound_score < -0.5:
        return 'Negative'
    else:
        return 'Neutral'

reviews_df['Sentiment'] = reviews_df['compound'].apply(classify_sentiment)
```

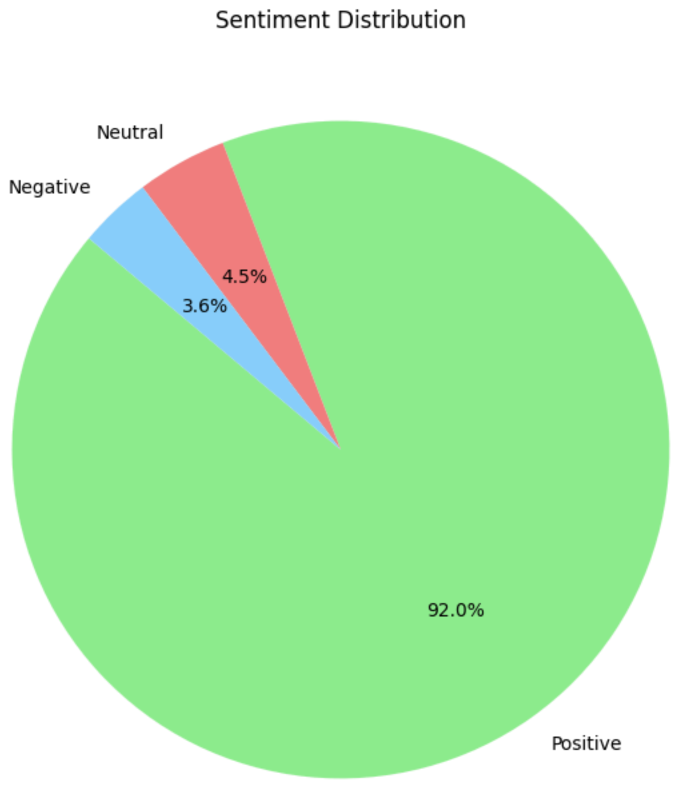
```
order = ['Review','Review_clean','Rating','pos','neu','neg','compound','Sentiment']
reviews_df = reviews_df[order]
```

```
reviews_df
```

	Review	Review_clean	Rating	pos	neu	neg	compound	Sentiment
10726	not recommend hotel did reviewers actually sta...	recommend hotel reviewer actually stay hotel g...	1	0.286	0.490	0.223	0.5367	Positive
14919	barcelona rocks, stayed hotel jazz girlfriend ...	barcelona rock stay hotel jazz girlfriend nigh...	4	0.185	0.686	0.129	0.9648	Positive
19098	ok hotel good location stayed night way beijin...	ok hotel good location stay night way beijing ...	3	0.428	0.572	0.000	0.9217	Positive
2450	great service nice pool ok beach lovely ground...	great service nice pool ok beach lovely ground...	4	0.313	0.631	0.057	0.9982	Positive
	surprising treat spent	surprising treat						

```
sentiment_counts = reviews_df['Sentiment'].value_counts()

# Create a pie chart
plt.figure(figsize=(8, 8))
plt.pie(sentiment_counts, labels=sentiment_counts.index, autopct='%1.1f%%', startangle=140, colors=['lightgreen', 'light
plt.title('Sentiment Distribution')
print(sentiment_counts)
# Show the plot
plt.show()
```

```
Positive    9422
Neutral      456
Negative     368
Name: Sentiment, dtype: int64
```

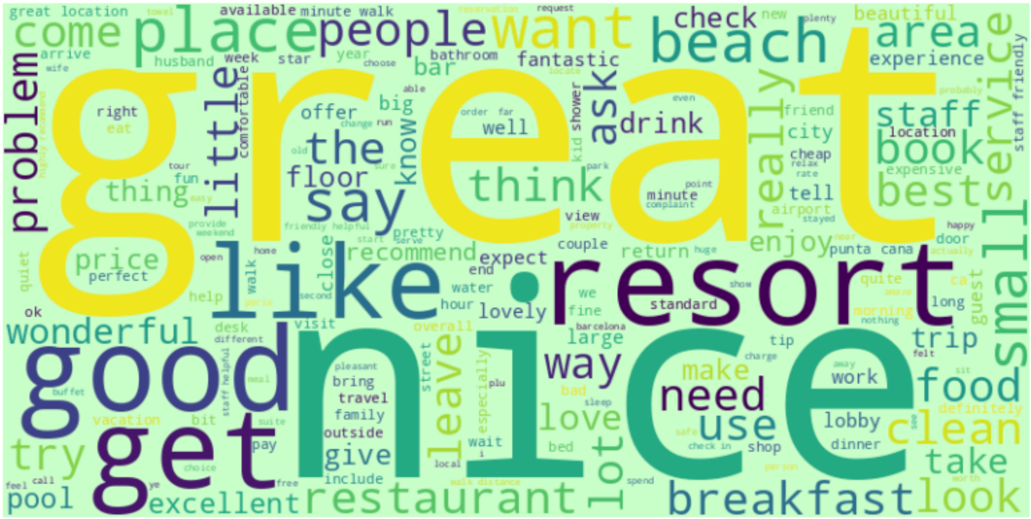


Wordcloud

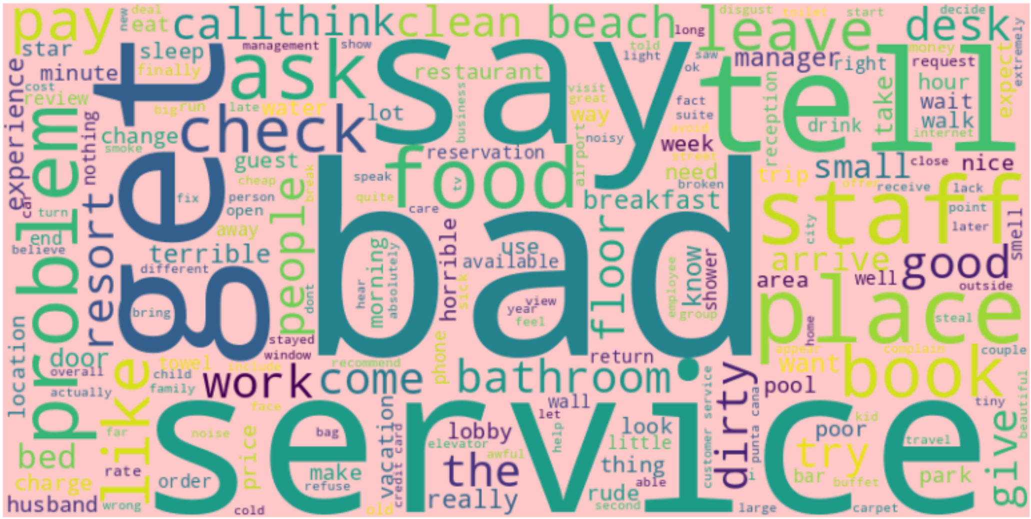
```
! pip install wordcloud
```

```
Requirement already satisfied: wordcloud in /usr/local/lib/python3.10/dist-packages (1.9.3)
Requirement already satisfied: numpy>=1.6.1 in /usr/local/lib/python3.10/dist-packages (from wordcloud) (1.25.2)
Requirement already satisfied: pillow in /usr/local/lib/python3.10/dist-packages (from wordcloud) (9.4.0)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.10/dist-packages (from wordcloud) (3.7.1)
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (1.2.0)
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (4.48.1)
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (1.4.5)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (23.2)
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (3.1.1)
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.10/dist-packages (from matplotlib->wordcloud) (2.8.2
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.7->matplotlib->wordclou
from wordcloud import WordCloud

# Custom stop words
custom_stopwords = set(['day', 'night', 'room', 'time','hotel','stay','go',"n't"])  # Add your custom stop words here

# Function to generate and display word cloud with custom color
def generate_wordcloud(text, title, color):
    wordcloud = WordCloud(width=800, height=400, background_color=color, stopwords=custom_stopwords).generate(text)

    # Plot the WordCloud image
    plt.figure(figsize=(10, 5))
    plt.imshow(wordcloud, interpolation='bilinear')
    plt.axis('off')
    plt.title(title)
    plt.show()

# Positive reviews
positive_text = ' '.join(reviews_df[reviews_df['Sentiment'] == 'Positive']['Review_clean'])
generate_wordcloud(positive_text, 'Word Cloud for Positive Reviews', '#CCFFCC')

# Negative reviews
negative_text = ' '.join(reviews_df[reviews_df['Sentiment'] == 'Negative']['Review_clean'])
generate_wordcloud(negative_text, 'Word Cloud for Negative Reviews', '#FFCCCC')

# Neutral reviews
neutral_text = ' '.join(reviews_df[reviews_df['Sentiment'] == 'Neutral']['Review_clean'])
generate_wordcloud(neutral_text, 'Word Cloud for Neutral Reviews', '#E0E0E0')
```

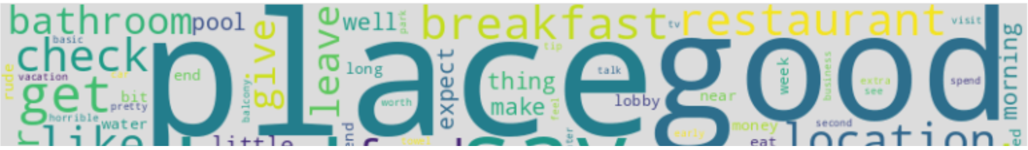
Word Cloud for Positive Reviews



Word Cloud for Negative Reviews



Word Cloud for Neutral Reviews



Feature Engineering

```
from sklearn.utils import resample

positive_reviews = reviews_df[reviews_df['Sentiment'] == 'Positive']
negative_reviews = reviews_df[reviews_df['Sentiment'] == 'Negative']
neutral_reviews = reviews_df[reviews_df['Sentiment'] == 'Neutral']
print(f"Number of positive reviews: {len(positive_reviews)}")
print(f"Number of negative reviews: {len(negative_reviews)}")
print(f"Number of neutral reviews: {len(neutral_reviews)}")
```

```
Number of positive reviews: 9422
Number of negative reviews: 368
Number of neutral reviews: 456
```

```
# Sample a subset from the majority class (Negative)
negative_downsampled = resample(negative_reviews, replace=True,
                                n_samples=len(positive_reviews) + len(neutral_reviews),
                                random_state=42)

# Combine downsampled majority class with minority classes
balanced_df = pd.concat([negative_downsampled, positive_reviews, neutral_reviews])

#Checking Count of balance data
sentiment_counts1 = balanced_df['Sentiment'].value_counts()
sentiment_counts1
```

```
Negative    9878
Positive    9422
Neutral      456
Name: Sentiment, dtype: int64
```

```
# Combine downsampled majority class with minority classes
balanced_df = pd.concat([negative_downsampled, positive_reviews, neutral_reviews])
```

```
balanced_df
```

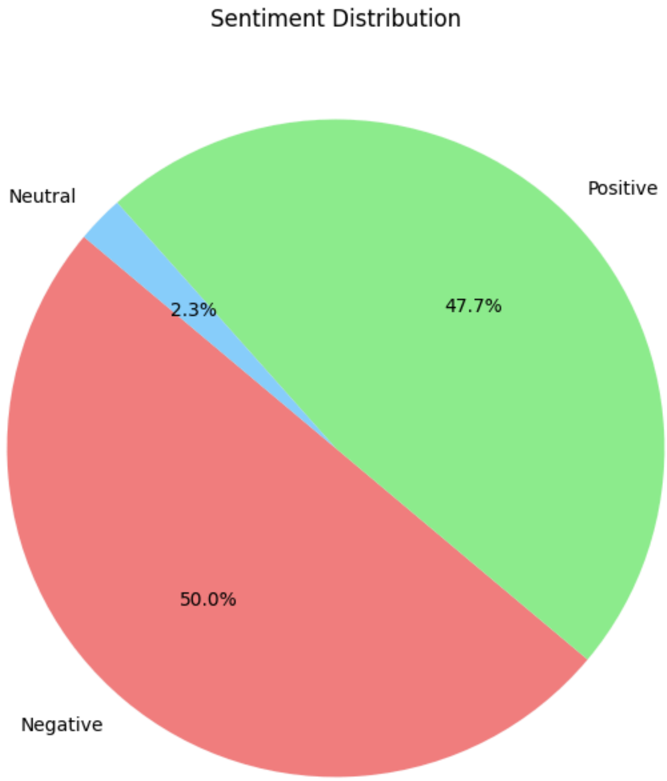
	Review	Review_clean	Rating	pos	neu	neg	compound	Sentiment
8596	customer service bad not recommend booked onli...	customer service bad recommend book online use...	1	0.126	0.668	0.206	-0.9511	Negative
20214	n't, chose hotel looked luxurious wanted nice ...	n't chose hotel look luxurious wanted nice con...	1	0.102	0.724	0.174	-0.5673	Negative
3316	not bad, not bad hotel needs renovation beach ...	bad bad hotel need renovation beach pool good ...	3	0.153	0.476	0.370	-0.6249	Negative
2498	terrible service n't stay, friend decided stay...	terrible service n't stay friend decided stay ...	1	0.094	0.610	0.295	-0.9909	Negative
	yuck, travel							

```
sentiment_counts1 = balanced_df['Sentiment'].value_counts()
sentiment_counts1
```

```
Negative    9878
Positive    9422
Neutral      456
Name: Sentiment, dtype: int64
```

```
# Create a pie chart
plt.figure(figsize=(8, 8))
plt.pie(sentiment_counts1, labels=sentiment_counts1.index, autopct='%1.1f%%', startangle=140, colors=[ 'lightcoral','lig
plt.title('Sentiment Distribution')
print(sentiment_counts1)
# Show the plot
plt.show()
```

```
Negative    9878
Positive    9422
Neutral      456
Name: Sentiment, dtype: int64
```



```
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.preprocessing import LabelEncoder


# Create a TF-IDF vectorizer
tfidf_vectorizer = TfidfVectorizer(max_features=5000, stop_words='english')

# Fit and transform the cleaned reviews
X = tfidf_vectorizer.fit_transform(balanced_df['Review_clean'])

# Get the target variable
y = balanced_df['Sentiment']

le = LabelEncoder()
y = le.fit_transform(y)
```

```
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=42)
```

```
print(type(X_train))
print(type(y_train))
```

```
<class 'scipy.sparse._csr.csr_matrix'>
<class 'numpy.ndarray'>
```

```
!pip install scipy
```

```
Requirement already satisfied: scipy in /usr/local/lib/python3.10/dist-packages (1.11.4)
Requirement already satisfied: numpy<1.28.0,>=1.21.6 in /usr/local/lib/python3.10/dist-packages (from scipy) (1.25.2)
```

```
import scipy
X_train = scipy.sparse.csr_matrix.toarray(X_train)
```

```
from sklearn.metrics import accuracy_score
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import GradientBoostingClassifier
from xgboost import XGBClassifier
from sklearn.model_selection import GridSearchCV
from lightgbm.sklearn import LGBMClassifier
from sklearn.naive_bayes import GaussianNB,MultinomialNB
from sklearn.naive_bayes import BernoulliNB
from sklearn.ensemble import AdaBoostClassifier
```

```
models=[DecisionTreeClassifier(),RandomForestClassifier(),KNeighborsClassifier(),XGBClassifier(),LGBMClassifier(),Multin
results=pd.DataFrame(columns=['Model','Train Accuracy','Test Accuracy'])
for model in models:
  model_name=model.__class__.__name__
  model.fit(X_train,y_train)
  train_predictions=model.predict(X_train)
  test_predictions=model.predict(X_test)
  train_accuracy=accuracy_score(y_train,train_predictions)
  test_accuracy=accuracy_score(y_test,test_predictions)

  results = results.append({'Model': model_name,
        'Train Accuracy': train_accuracy,
        'Test Accuracy': test_accuracy
    }, ignore_index=True)
  print(f'Classification Report {model_name}')
  print(classification_report(y_test,test_predictions))
  print('===========================================================================================')
```

```
<ipython-input-56-7ab9d1b89b48>:11: FutureWarning: The frame.append method is deprecated and will be removed from pandas in a fu
  results = results.append({'Model': model_name,
Classification Report DecisionTreeClassifier
              precision    recall  f1-score   support

           0       0.96      1.00      0.98      1988
           1       0.10      0.07      0.08        90
           2       0.97      0.94      0.95      1874

    accuracy                           0.95      3952
   macro avg       0.67      0.67      0.67      3952
weighted avg       0.94      0.95      0.94      3952

===========================================================================================
<ipython-input-56-7ab9d1b89b48>:11: FutureWarning: The frame.append method is deprecated and will be removed from pandas in a fu
  results = results.append({'Model': model_name,
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
  _warn_prf(average, modifier, msg_start, len(result))
Classification Report RandomForestClassifier
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      1988
           1       0.00      0.00      0.00        90
           2       0.96      1.00      0.98      1874

    accuracy                           0.98      3952
   macro avg       0.65      0.67      0.66      3952
weighted avg       0.95      0.98      0.97      3952

==========================================================================================
<ipython-input-56-7ab9d1b89b48>:11: FutureWarning: The frame.append method is deprecated and will be removed from pandas in a fu
  results = results.append({'Model': model_name,
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
  _warn_prf(average, modifier, msg_start, len(result))
Classification Report KNeighborsClassifier
              precision    recall  f1-score   support

           0       0.96      1.00      0.98      1988
           1       0.00      0.00      0.00        90
           2       0.96      0.96      0.96      1874

    accuracy                           0.96      3952
   macro avg       0.64      0.65      0.65      3952
weighted avg       0.94      0.96      0.95      3952

==========================================================================================
<ipython-input-56-7ab9d1b89b48>:11: FutureWarning: The frame.append method is deprecated and will be removed from pandas in a fu
  results = results.append({'Model': model_name,
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score a
```

```
results['Rank']=results['Test Accuracy'].rank(ascending=False)
print(results)
```

```
                    Model  Train Accuracy  Test Accuracy  Rank
0  DecisionTreeClassifier        1.000000       0.948381   5.0
1  RandomForestClassifier        1.000000       0.976215   1.0
2    KNeighborsClassifier        0.967413       0.958249   3.0
3           XGBClassifier        0.999177       0.022773   8.0
4          LGBMClassifier        1.000000       0.970142   2.0
5           MultinomialNB        0.954948       0.953188   4.0
6             BernoulliNB        0.952733       0.936994   7.0
7      AdaBoostClassifier        0.941850       0.939271   6.0
```

```
'''from sklearn.model_selection import GridSearchCV, train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score

# Hyperparameter tuning for RandomForestClassifier
param_grid_rf = {
    'n_estimators': [50, 100],
    'max_depth': [None, 10, 20],
    'min_samples_split': [2, 5],
    'min_samples_leaf': [1, 2, 4]
}

rf_model = RandomForestClassifier(random_state=42)
grid_search_rf = GridSearchCV(rf_model, param_grid=param_grid_rf, cv=5, scoring='accuracy')
grid_search_rf.fit(X_train, y_train)

# Get the best parameters for RandomForestClassifier
best_params_rf = grid_search_rf.best_params_
print("RandomForestClassifier Best Parameters:", best_params_rf)'''
```

```
'from sklearn.model_selection import GridSearchCV, train_test_split\nfrom sklearn.ensemble import RandomForestClassifier\nfrom skl
earn.metrics import accuracy_score\n\n# Hyperparameter tuning for RandomForestClassifier\nparam_grid_rf = {\n    \'n_estimators\':
[50, 100],\n    \'max_depth\': [None, 10, 20],\n    \'min_samples_split\': [2, 5],\n    \'min_samples_leaf\': [1, 2, 4]\n}\n\nrf_m
odel = RandomForestClassifier(random_state=42)\ngrid_search_rf = GridSearchCV(rf_model, param_grid=param_grid_rf, cv=5, scoring=
\'accuracy\')\ngrid_search_rf.fit(X_train, y_train)\n\n# Get the best parameters for RandomForestClassifier\nbest_params_rf = grid
_search_rf.best_params_\nprint("RandomForestClassifier Best Parameters:", best_params_rf)'
```

```
# Train the RandomForestClassifier with the best parameters
best_rf_model = RandomForestClassifier(random_state=42,max_depth = None, min_samples_leaf = 1, min_samples_split = 5, n_
best_rf_model.fit(X_train, y_train)

# Evaluate on the test set
rf_test_predictions = best_rf_model.predict(X_test)
rf_test_accuracy = accuracy_score(y_test, rf_test_predictions)


rf_test_predictions
```

```
    array([2, 2, 2, ..., 0, 2, 2])
    RandomForestClassifier Test Accuracy: 0.9764676113360324
```

RandomForestClassifier Best Parameters: {'max_depth': None, 'min_samples_leaf': 1, 'min_samples_split': 5, 'n_estimators': 100}

RandomForestClassifier Test Accuracy: 0.9764676113360324

```
'''from sklearn.model_selection import GridSearchCV, train_test_split
from lightgbm import LGBMClassifier
from sklearn.metrics import accuracy_score



# Hyperparameter tuning for LGBMClassifier
param_grid_lgbm = {
    'n_estimators': [100],
    'max_depth': [None],
    'learning_rate': [0.01, 0.1],
    'num_leaves': [31, 50,100]
}

lgbm_model = LGBMClassifier(random_state=42)
grid_search_lgbm = GridSearchCV(lgbm_model, param_grid=param_grid_lgbm, cv=5, scoring='accuracy')
grid_search_lgbm.fit(X_train, y_train)

# Get the best parameters for LGBMClassifier
best_params_lgbm = grid_search_lgbm.best_params_

# Train the LGBMClassifier with the best parameters
best_lgbm_model = LGBMClassifier(random_state=42, **best_params_lgbm)
best_lgbm_model.fit(X_train, y_train)

# Evaluate on the test set
lgbm_test_predictions = best_lgbm_model.predict(X_test)
lgbm_test_accuracy = accuracy_score(y_test, lgbm_test_predictions)

# Print the results
print("\nLGBMClassifier Best Parameters:", best_params_lgbm)
print("LGBMClassifier Test Accuracy:", lgbm_test_accuracy)'''
```

```
    'from sklearn.model_selection import GridSearchCV, train_test_split\nfrom lightgbm i
    mport LGBMClassifier\nfrom sklearn.metrics import accuracy_score\n\n\n# Hyperparamet
    er tuning for LGBMClassifier\nparam_grid_lgbm = {\n    \'n_estimators\': [100],\n
    \'max_depth\': [None],\n    \'learning_rate\': [0.01, 0.1],\n    \'num_leaves\': [3
    1, 50,100]\n}\n\nlgbm_model = LGBMClassifier(random_state=42)\ngrid_search_lgbm = Gr
    idSearchCV(lgbm_model, param_grid=param_grid_lgbm, cv=5, scoring=\'accuracy\')\ngrid
    _search_lgbm.fit(X_train, y_train)\n\n# Get the best parameters for LGBMClassifier\n
    best_params_lgbm = grid_search_lgbm.best_params_\n\n# Train the LGBMClassifier with
```

LGBMClassifier Best Parameters: {'learning_rate': 0.1, 'max_depth': None,