BÁO CÁO ĐỒ ÁN CUỐI KỲ

MÔN HỌC: PYTHON CHO KHOA HỌC DỮ LIỆU

ĐỀ TÀI: NATURAL LANGUAGE PROCESSING

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Nội dung báo cáo:

Bước 1: Collect Data

Cài đặt thư viện

```
import pandas as pd
import numpy as np
from bs4 import BeautifulSoup
import requests
```

Create a comprehensive dataset by scraping data items from the website: https://www.trustpilot.com/review/www.facebook.com?

Use the requests and BeautifulSoup module to scrape the reviews of Facebook.

Create an empty list to store the reviews, rating stars, date and links of reviews

Find all the *a* elements with the *href* attribute in each div element, get its *href* value using get mothod and append it to the *links* list.

```
#create an empty list to collect all reviews
reviews  = []

#create an empty list to collect rating stars
stars = []

#create an empty list to collect date
date = []

##create an empty list to collect all links of reviews
links=[]
```

Gather relevant information for each data item.

```
for i in range(1,101):
    page = requests.get(f"https://www.trustpilot.com/review/www.facebook.com?page={i}")

    soup = BeautifulSoup(page.content, "html5")
    for k in soup.find_all('div',class_='styles_reviewContent__0Q2Tg'):
        links.append(k.find('a').get('href'))
```

```
for link in links:
    page = requests.get('https://www.trustpilot.com' + link)
    soup = BeautifulSoup(page.content, "html5")

    review_elements = soup.find_all("p", class_="typography_body-l__KUYFJ typography_appearance-default__AAY17 typography_color-b
    if review_elements:
        for item in review_elements:
            reviews.append(item.text)
    else:
        reviews.append(np.nan)

    for item in soup.find_all("time"):
        date.append(item.get('datetime'))

    for item in soup.find_all('div', class_='styles_reviewHeader__iU9Px'):
        stars.append(item.get('data-service-review-rating'))
```

Create a dataframe from the lists of information extracted from the web links.

The dataframe has three columns *reviews*, *date* and *star* corresponding to the lists above.

```
df = pd.DataFrame({'reviews': reviews, 'date': date, 'stars': stars})
```

Save the dataframe to a file called *reviews.csv*

```
df.to_csv("C:/Users/ACER/Downloads/reviews.csv", encoding='utf-8')
```

Bước 2: Clean Data

Import neccessary libraries

```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import re
```

Collect data of facebook reviews from *reviews.csv*

```
df = pd.read_csv("/content/sample_file/reviews.csv", index_col=0)
df.head(10)
```

	reviews	date	stars
0	Facebook full of romance scams, vehicle scams,...	2023-11-12T17:26:52.000Z	1
1	FB Marketplace a scammers paradise.I'd say mor...	2023-11-10T17:31:57.000Z	1
2	Absolutely rubbish they encourage you to repor...	2023-11-11T10:29:43.000Z	1
3	1 star is too generous. My Facebook account ac...	2023-11-12T00:07:17.000Z	1
4	Facebook has let someone hack a dead man's acc...	2023-11-12T22:15:26.000Z	1
5	Facebook account got hacked and I can no longe...	2023-11-11T10:30:33.000Z	1
6	One of the things I love most about Facebook i...	2023-11-08T12:17:29.000Z	5
7	FB MARKETPLACE FULL OF SCAMMERS.YOU REPORT SCA...	2023-11-10T22:24:52.000Z	1
8	Community guidelines are total mess. Works for...	2023-11-13T03:59:36.000Z	1
9	Wish there was a no star selection!! My Facebo...	2023-11-09T16:39:42.000Z	1

Convert datetime data in *date* column to standard format *Year - Month – Date*

```
df['date'] = pd.to_datetime(df['date']).apply(lambda x: x.strftime('%Y-%m-%d'))
```

Use the Natural Language Toolkit library to lemmatize words by WordNet built-in morphy function

```
from nltk.stem import WordNetLemmatizer
from nltk.corpus import stopwords
lemma = WordNetLemmatizer()
```

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

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to /root/nltk_data...
```

Create an empty list called *corpus* to store the processed reviews

Loop over each review in the reviews column to clean, normalize and lemmatize each review using regular expression, string methods and WorkNetLemmatizer

Return a list of proccesed reviews which have been prepared for further analysis

```
corpus =[]


for rev in df['reviews']:
    rev = re.sub('[^a-zA-Z0-9]',' ', str(rev))
    rev = rev.lower()
    rev = rev.split()
    rev = [lemma.lemmatize(word) for word in rev if word not in set(stopwords.words("english"))]
    rev = " ".join(rev)
    corpus.append(rev)
```

Create a new column of the dataframe *df* named *corpus*

```
df['corpus']=corpus
```

Replace data in *date* columns with the converted data

```
df['date'] = pd.to_datetime(df['date'])
```

Display summary information of the dataframe

```
df.dtypes
```

```
reviews            object
date       datetime64[ns]
stars               int64
corpus             object
dtype: object
```

Show the frequency of star rating data in the *star* column

```
df['stars'].value_counts()
```

```
1    1648
5     161
2      68
4      67
3      56
Name: stars, dtype: int64
```

Check sum of missing values in each column of the dataframe

```
df.isna().sum()
```

```
reviews    156
date         0
stars        0
corpus       0
dtype: int64
```

Remove any rows in the *reviews* column which contain missing values

```
df.drop(df[df['reviews'].isnull() == True].index, axis=0, inplace=True)
```

```
df.isna().sum()
```

```
reviews    0
date       0
stars      0
corpus     0
dtype: int64
```

Check the size of dataset after removing missing values

```
df.shape
```

```
(1844, 4)
```

Reset index of the dataframe

```
df.reset_index(drop=True)
```

	reviews	date	stars	corpus
0	Facebook full of romance scams, vehicle scams,...	2023-11-12	1	facebook full romance scam vehicle scam crypto...
1	FB Marketplace a scammers paradise.I'd say mor...	2023-11-10	1	fb marketplace scammer paradise say half add s...
2	Absolutely rubbish they encourage you to repor...	2023-11-11	1	absolutely rubbish encourage report bullying a...
3	1 star is too generous. My Facebook account ac...	2023-11-12	1	1 star generous facebook account active since ...
4	Facebook has let someone hack a dead man's acc...	2023-11-12	1	facebook let someone hack dead man account loa...
...	...	...	...	...
1839	Thoroughly recommended, quick and efficient, m...	2022-01-22	5	thoroughly recommended quick efficient many th...
1840	Facebook allows Fake & "Alias" accounts for pe...	2022-01-22	1	facebook allows fake alias account people bad ...
1841	Poor standards and support. Reported video whe...	2022-01-22	1	poor standard support reported video animal ki...
1842	This is nothing less than the world's biggest ...	2022-01-22	1	nothing le world biggest pedophile site need s...
1843	There is some good, some bad here. For marketi...	2022-01-21	3	good bad marketing purpose amazing many bug ac...

1844 rows × 4 columns

Save the dataframe to a file called *cleaned-BA-reviews.csv*

```
df.to_csv("/content/sample_file/cleaned-reviews.csv")
```

Bước 3: EDA

1. **Import data**

```
import pandas as pd
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px

import datetime as dt

from wordcloud import WordCloud, STOPWORDS
```

```
df = pd.read_csv("cleaned-reviews.csv",index_col=0)
```

```
df = df.reset_index()
```

```
df
```

	index	reviews	date	stars	corpus
0	0	Facebook full of romance scams, vehicle scams,...	2023-11-12	1	facebook full romance scam vehicle scam crypto...
1	1	FB Marketplace a scammers paradise.I'd say mor...	2023-11-10	1	fb marketplace scammer paradise say half add s...
2	2	Absolutely rubbish they encourage you to repor...	2023-11-11	1	absolutely rubbish encourage report bullying a...
3	3	1 star is too generous. My Facebook account ac...	2023-11-12	1	1 star generous facebook account active since ...
4	4	Facebook has let someone hack a dead man's acc...	2023-11-12	1	facebook let someone hack dead man account loa...
...	...	...	...	...	...
1839	1995	Thoroughly recommended, quick and efficient, m...	2022-01-22	5	thoroughly recommended quick efficient many th...
1840	1996	Facebook allows Fake & "Alias" accounts for pe...	2022-01-22	1	facebook allows fake alias account people bad ...
1841	1997	Poor standards and support. Reported video whe...	2022-01-22	1	poor standard support reported video animal ki...
1842	1998	This is nothing less than the world's biggest ...	2022-01-22	1	nothing le world biggest pedophile site need s...
1843	1999	There is some good, some bad here. For marketi...	2022-01-21	3	good bad marketing purpose amazing many bug ac...

1844 rows × 5 columns

2. Summarizing Reviews

What is the average overall rating given for rating?

```
df['stars'].mean()
```

```
1.4126898047722343
```

What is the total counts for each ratings?

Create a new dataframe called *df_ratings* to store the frequency of each value in *star* column.

Calculate the percentage of each star rating and round it to two decimal places, then add these values to *pct_values* column.

Dataframe *df_ratings* shows the distribution of star ratings and their percentages in the reviews.

```
df_ratings = pd.DataFrame(df.stars.value_counts())
pct_values = (df_ratings.stars.values/ df_ratings.stars.values.sum() *100).tolist()
pct_values = [round(x,2) for x in pct_values]
df_ratings['pct_values'] = pct_values
```

Reset index of the dataframe.

```
df_ratings = df_ratings.reset_index()
```

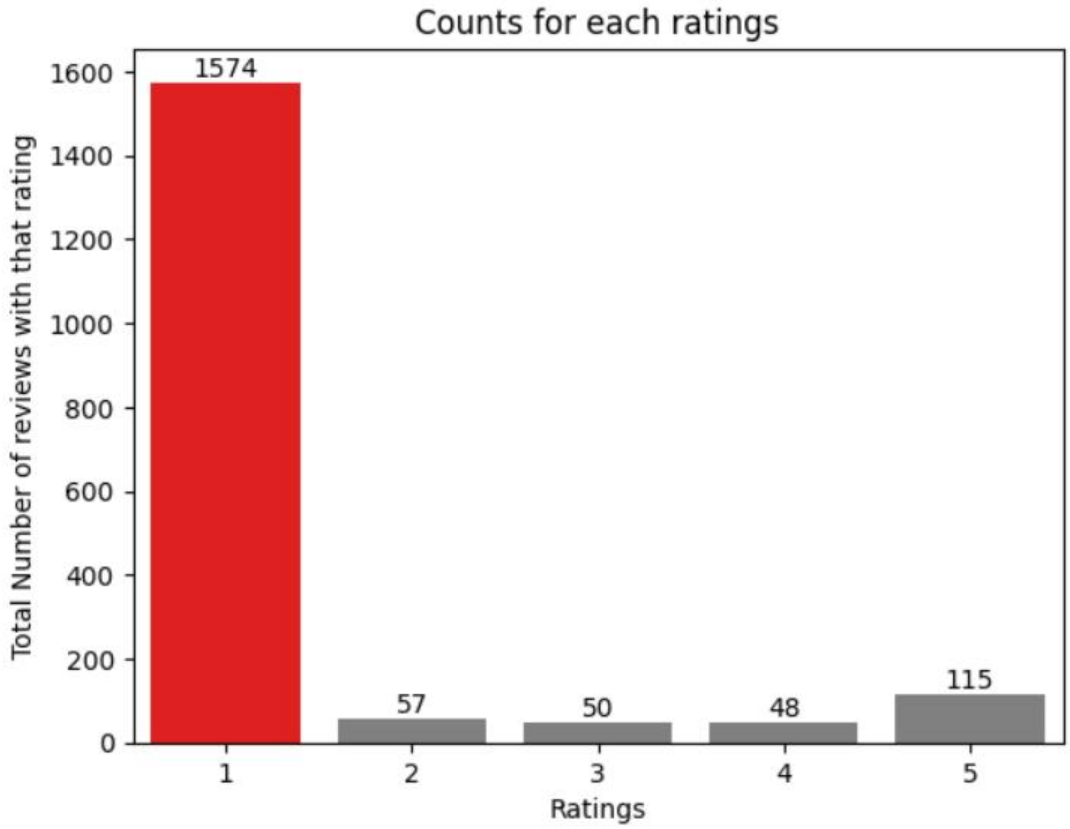
Replace columns' name of the dataframe.

```
df_ratings.rename(columns={'index':'Stars', 'stars':'total_counts'}, inplace=True)
```

Create a bar plot which shows the distribution of star ratings and their counts in the reviews, with the highest bar highlighted in red and the others in grey.

```
clrs = ['Red' if (x ==  max(df_ratings.total_counts)) else 'grey' for x in df_ratings.total_counts ]
ax = sns.barplot(x=df_ratings.Stars, y=df_ratings.total_counts, data=df_ratings, errwidth=0,
                 palette=clrs)

ax.bar_label(ax.containers[0])

ax.set_xlabel("Ratings")
ax.set_ylabel("Total Number of reviews with that rating")
ax.set_title("Counts for each ratings")
```

```
Text(0.5, 1.0, 'Counts for each ratings')
```



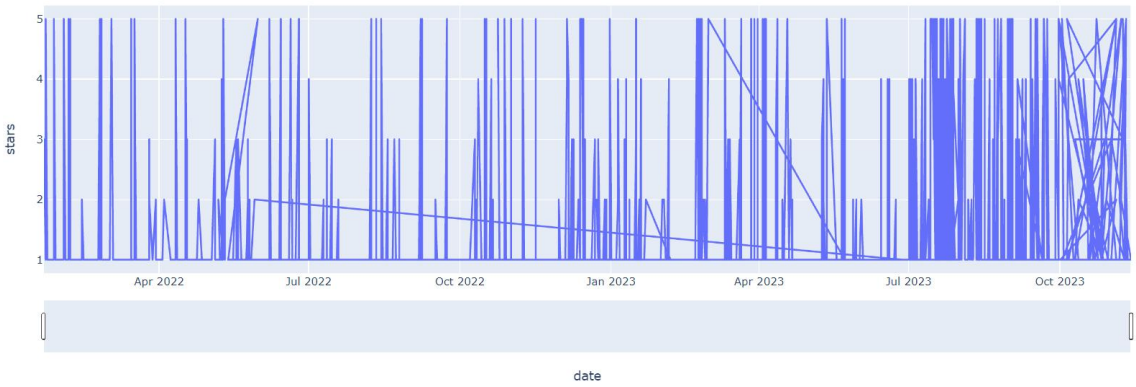
Time Series Analysis

Create an interactive line plot to visualize how a numerical value *stars* changes over time *date*.

Enhance the plot's interactivity by adding a range slider beneath the x-axis

This slider allows users to to zoom in and out on specific sections of the data.

```
fig = px.line(df, x='date', y="stars")
fig.update_xaxes(rangeslider_visible=True)
fig.show()
```



Create and visualize a word cloud, a visual representation of text data where word frequencies are depicted by font size and placement.

It helps identify prominent themes and patterns within a body of text in thereviews, making it easier to grasp key concepts and trends.

Create a set of English stop words for efficient filtering. Then combine text data in a column named *corpus* in *df* dataframe into a single string, preparing for word cloud creation.

Generate the Word Cloud with specified parameters.

```
import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords
reviews = " ".join(df.corpus)
plt.figure(figsize=(20,10))

stopwords = set(stopwords.words('english'))


wordcloud = WordCloud(height=600,width=600,max_font_size=100, max_words=500, stopwords=stopwords).generate(reviews)

plt.imshow(wordcloud, interpolation='bilinear')
plt.axis("off")
plt.show()
```

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

Identify the most frequent words within the body of text in the reviews. This helps understand common themes, patterns, and word usage in the text.

Split the text in reviews into a list of individual words.

Create a *FreqDist* object to count word frequencies and extract the 20 most frequent words. Then create a dataframe to contain their frequencies.

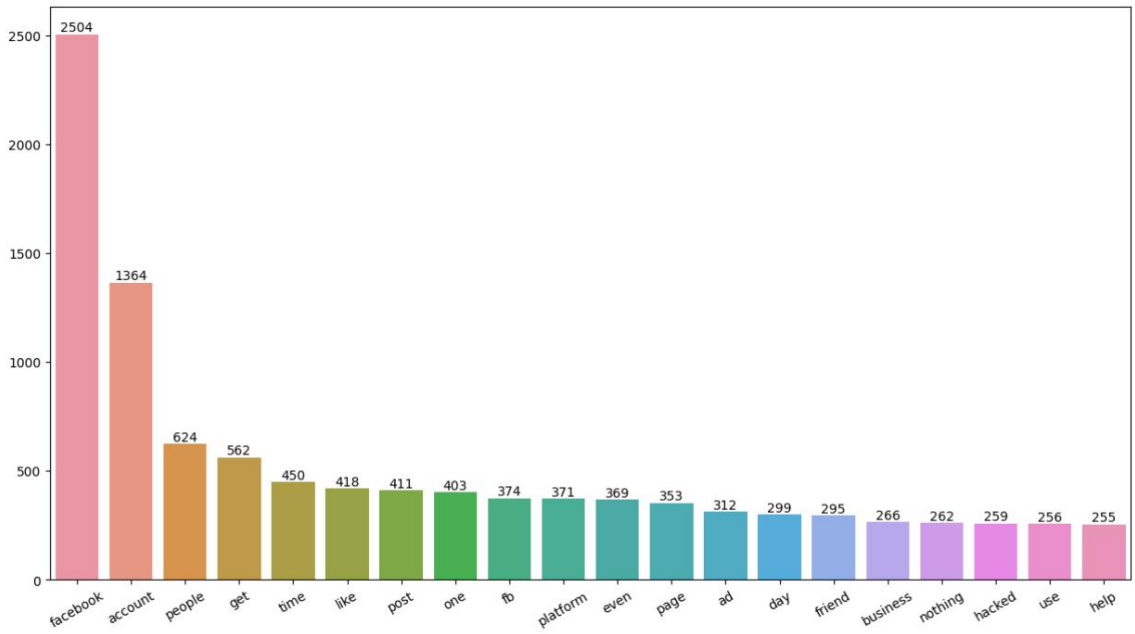
```
from nltk import ngrams
from nltk.probability import FreqDist


new_words = reviews.split(" ")


nlp_words=FreqDist(new_words).most_common(20)


all_fdist = pd.Series(dict(nlp_words))
```

Visualize a bar plot which shows the frequencies of the most common words in a dataset *all_fdist*, making it easier to grasp word usage patterns.

Rotate the x-axis labels (words) by 30 degrees to prevent overlapping and improve readability.

```
fig, ax = plt.subplots(figsize=(15,8))
all_plot = sns.barplot(x=all_fdist.index, y=all_fdist.values, ax=ax)
all_plot.bar_label(all_plot.containers[0])
plt.xticks(rotation=30)
```

```
(array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
        17, 18, 19]),
 [Text(0, 0, 'facebook'),
  Text(1, 0, 'account'),
  Text(2, 0, 'people'),
  Text(3, 0, 'get'),
  Text(4, 0, 'time'),
  Text(5, 0, 'like'),
  Text(6, 0, 'post'),
  Text(7, 0, 'one'),
  Text(8, 0, 'fb'),
  Text(9, 0, 'platform'),
  Text(10, 0, 'even'),
  Text(11, 0, 'page'),
  Text(12, 0, 'ad'),
  Text(13, 0, 'day'),
  Text(14, 0, 'friend'),
  Text(15, 0, 'business'),
  Text(16, 0, 'nothing'),
  Text(17, 0, 'hacked'),
  Text(18, 0, 'use'),
  Text(19, 0, 'help')])
```

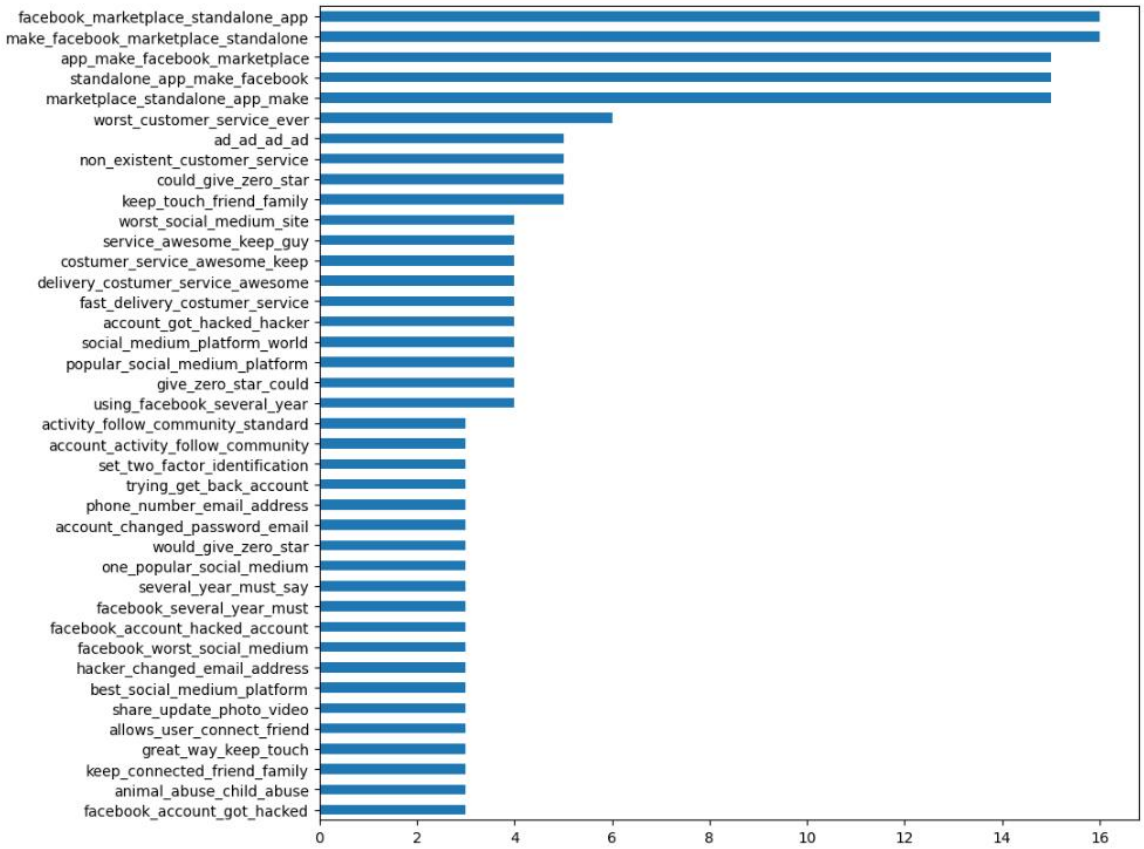


Identify and visualize the most common word sequences (n-grams) within a body of text, revealing patterns of word usage and common phrases.

Define get_freq_dist function :

- Create n-grams (sequences of number_of_ngrams words) in the input text
- Calculate n-gram frequencies and extract the 40 most frequent n-grams.
- Sort the n-grams by frequency and join words within each n-gram using underscores.
- Create a horizontal bar plot which shows frequencies of n-grams.

```
import nltk.collocations as collocations
from nltk import bigrams

def get_freq_dist(new_words,number_of_ngrams ):
    from nltk import ngrams


    ngrams = ngrams(new_words, number_of_ngrams)


    ngram_fd = FreqDist(ngrams).most_common(40)


    ngram_joined = {'_'.join(k):v for k,v in sorted(ngram_fd, key=lambda item:item[1])}


    ngram_freqdist = pd.Series(ngram_joined)
    plt.figure(figsize=(10,10))
    ax = ngram_freqdist.plot(kind="barh")

    return ax


get_freq_dist(new_words,4)
```



3. Detecting Sentiment in text

VADER Sentiment Scoring

Analyze the sentiment (positive, negative, or neutral) of text data within a DataFrame using the VADER sentiment analysis tool.

Create an *SentimentIntensityAnalyzer* object for sentiment analysis.

Prepare result dictionary by creating an empty dictionary to store sentiment scores for each text.

Loop over each row of the dataframe and extract the text and index values for the current row.

Apply sentiment analysis to the text using VADER and store the resulting sentiment scores (positive, negative, neutral and compound) in the *res* dictionary.

```
%%capture
nltk.download('vader_lexicon')
from nltk.sentiment.vader import SentimentIntensityAnalyzer
from tqdm.notebook import tqdm

vds = SentimentIntensityAnalyzer()

res = {}
for i, row in tqdm(df.iterrows(), total=len(df)):
    text = row['corpus']
    myindex = row['index']
    res[myindex] = vds.polarity_scores(text)
```

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

Integrate sentiment scores generated by VADER back into the original dataframe

Create a combined dataset named *vaders* for further analysis and exploration of sentiment alongside other data.

```
vaders = pd.DataFrame(res).T
vaders = vaders.reset_index().rename(columns={'index': 'index'})
vaders = vaders.merge(df, how='left')
```

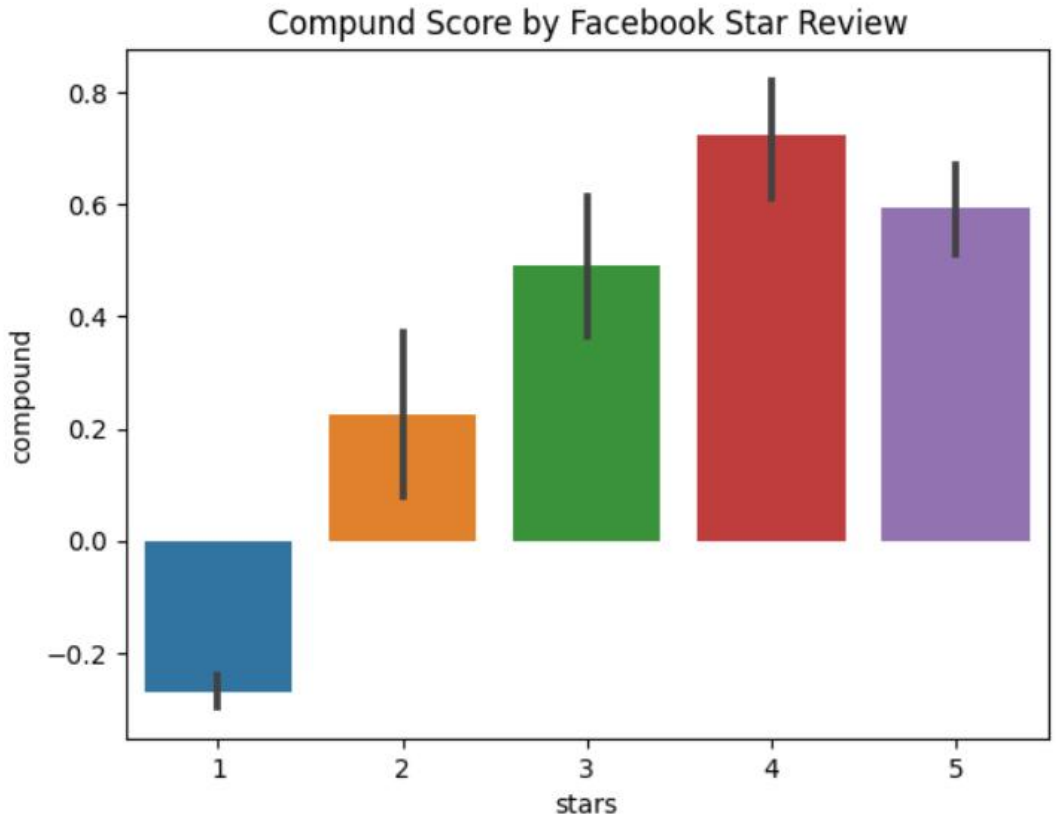
```
vaders.head()
```

	index	neg	neu	pos	compound	reviews	date	stars	corpus
0	0	0.292	0.433	0.275	-0.4490	Facebook full of romance scams, vehicle scams,...	2023-11-12	1	facebook full romance scam vehicle scam crypto...
1	1	0.318	0.552	0.129	-0.9186	FB Marketplace a scammers paradise.I'd say mor...	2023-11-10	1	fb marketplace scammer paradise say half add s...
2	2	0.390	0.489	0.121	-0.9818	Absolutely rubbish they encourage you to repor...	2023-11-11	1	absolutely rubbish encourage report bullying a...
3	3	0.170	0.546	0.284	0.8940	1 star is too generous. My Facebook account ac...	2023-11-12	1	1 star generous facebook account active since ...
4	4	0.305	0.594	0.101	-0.7845	Facebook has let someone hack a dead man's acc...	2023-11-12	1	facebook let someone hack dead man account loa...

Create a bar plot which shows the relationship between the compound sentiment scores (overall sentiment) of text data and their corresponding star ratings, supporting in understanding how sentiment aligns with numerical ratings.

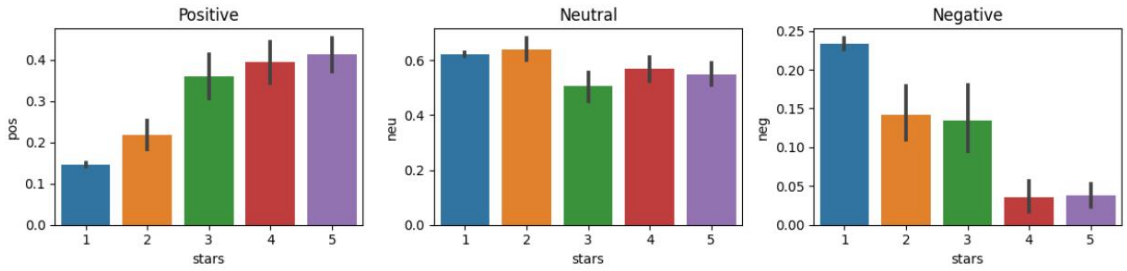
For Compound Score

```
ax = sns.barplot(data=vaders, x='stars', y='compound')
ax.set_title('Compund Score by Facebook Star Review')
plt.show()
```



For Positive, Neutral and Negative Scores

```
fig, axs = plt.subplots(1, 3, figsize=(12, 3))
sns.barplot(data=vaders, x='stars', y='pos', ax=axs[0])
sns.barplot(data=vaders, x='stars', y='neu', ax=axs[1])
sns.barplot(data=vaders, x='stars', y='neg', ax=axs[2])
axs[0].set_title('Positive')
axs[1].set_title('Neutral')
axs[2].set_title('Negative')
plt.tight_layout()
plt.show()
```



Roberta Pretrained Model

Use a pre-trained language model for text classification.

```
from transformers import AutoTokenizer
from transformers import AutoModelForSequenceClassification
from scipy.special import softmax
```

Specify model name. This model is based on Roberta architecture, a powerful language model known for its performance in various text-related tasks.

Load the tokenizer with specified model to preprocess text input into numerical tokens.

Load the actual pre-trained model.

```
MODEL = f"cardiffnlp/twitter-roberta-base-sentiment"
tokenizer = AutoTokenizer.from_pretrained(MODEL)
model = AutoModelForSequenceClassification.from_pretrained(MODEL)
```

```
config.json:   0%|          | 0.00/747 [00:00<?, ?B/s]
vocab.json:   0%|          | 0.00/899k [00:00<?, ?B/s]
merges.txt:   0%|          | 0.00/456k [00:00<?, ?B/s]
special_tokens_map.json:   0%|          | 0.00/150 [00:00<?, ?B/s]
pytorch_model.bin:   0%|          | 0.00/499M [00:00<?, ?B/s]
```

Process text input using a pre-trained Roberta model and return sentiment polarity scores.

Tokenize the input text, then pass tokens to the model.

Extract the raw sentiment scores from model's output and convert them into a Numpy array.

Normalize the scores into probabilities between 0 and 1 and create a dictionary to organize scores for each different classes (negative, neutral, positive).

```
def polarity_scores_roberta(example):
    encoded_text = tokenizer(example, return_tensors='pt')
    output = model(**encoded_text)
    scores = output[0][0].detach().numpy()
    scores = softmax(scores)
    scores_dict = {
        'roberta_neg' : scores[0],
        'roberta_neu' : scores[1],
        'roberta_pos' : scores[2]
    }
    return scores_dict
```

Combine and compare

Apply two different sentiment analysis techniques (VADER and RoBERTa) to text data within a dataframe, store results combined for each text and handle potential errors during processing.

```
res = {}
for i, row in tqdm(df.iterrows(), total=len(df)):
    try:
        text = row['corpus']
        myindex = row['index']
        vader_result = vds.polarity_scores(text)
        vader_result_rename = {}
        for key, value in vader_result.items():
            vader_result_rename[f"vader_{key}"] = value
        roberta_result = polarity_scores_roberta(text)
        both = {**vader_result_rename, **roberta_result}
        res[myindex] = both
    except RuntimeError:
        print(f'Broke for id {myindex}')
```

```
  0%|          | 0/1844 [00:00<?, ?it/s]
```

Integrate sentiment analysis results back into the original dataframe.

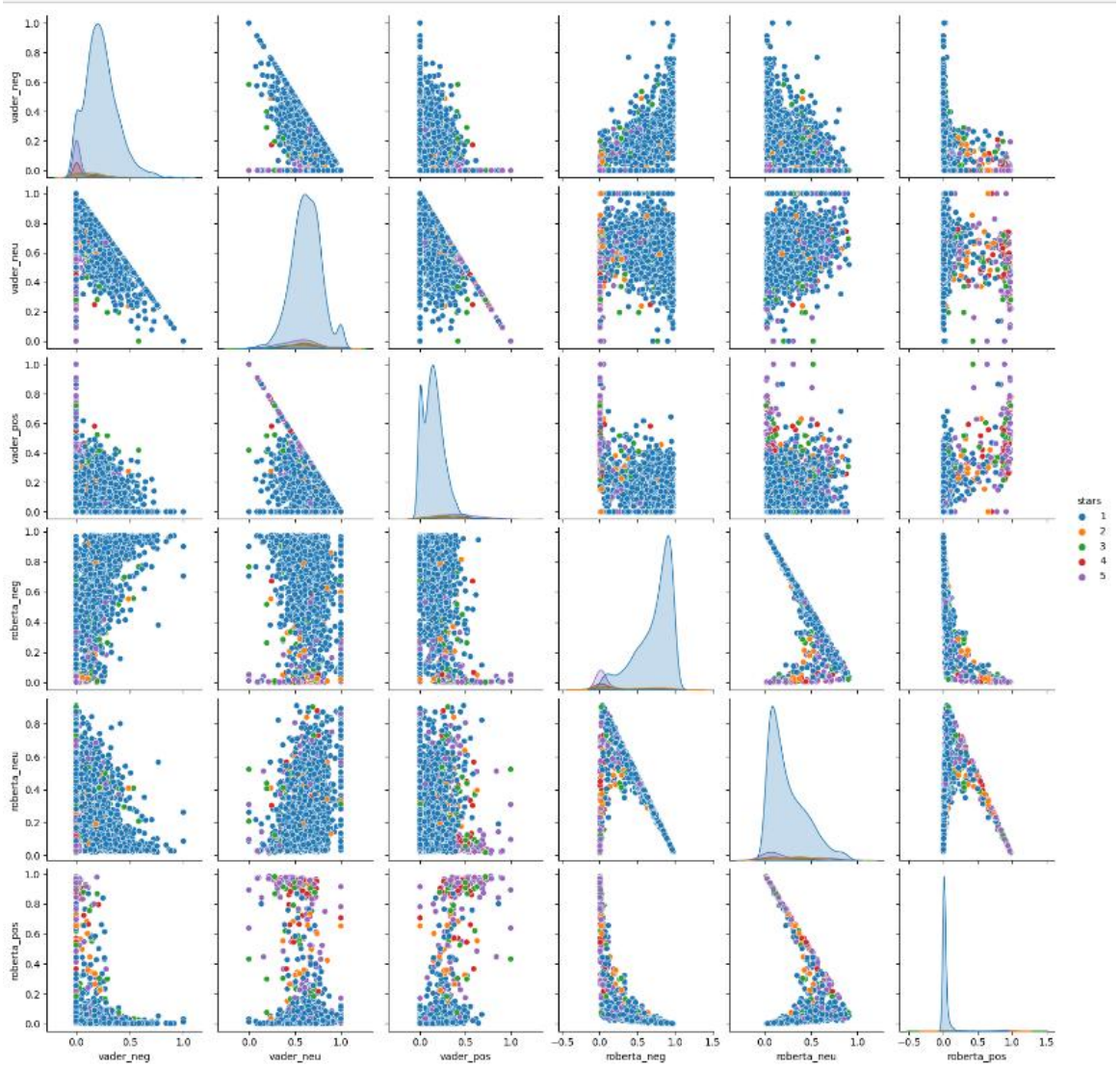
Create a combined dataset named *results_df* that facilitates further analysis and exploration of sentiment alongside other data attributes.

```
results_df = pd.DataFrame(res).T
results_df = results_df.reset_index().rename(columns={'index': 'index'})
results_df = results_df.merge(df, how='left')
```

Create a multi-panel plot which shows relationships between sentiment scores from two different methods (VADER and RoBERTa) and how these scores vary across different star ratings.

This supports in understanding how sentiment aligns with numerical feedback and how different sentiment analysis techniques compare.

```
sns.pairplot(data=results_df,
             vars=['vader_neg', 'vader_neu', 'vader_pos',
                   'roberta_neg', 'roberta_neu', 'roberta_pos'],
             hue='stars',
             palette='tab10')
plt.show()
```



4. Sentiment Analyst using Machine Learning

Create a new column named label of dataframe df.

Checks if each element in the stars column. And if the star rating is equal 1, 2, 3, assign neg to the corresponding element in label column, indicating a negative review. If not, assign pos instead, indicating a positive review.

```
df['label'] = np.where(df['stars'].isin([1, 2, 3]), 'neg', 'pos')
```

Prepare data for machine learning by selecting features and extracting labels.

X are the independent variables.

y is the dependent variable.

```
X = df.iloc[:,4:5]
y=df['label']
```

```
X
```

	corpus
0	facebook full romance scam vehicle scam crypto...
1	fb marketplace scammer paradise say half add s...
2	absolutely rubbish encourage report bullying a...
3	1 star generous facebook account active since ...
4	facebook let someone hack dead man account loa...
...	...
1839	thoroughly recommended quick efficient many th...
1840	facebook allows fake alias account people bad ...
1841	poor standard support reported video animal ki...
1842	nothing le world biggest pedophile site need s...
1843	good bad marketing purpose amazing many bug ac...

1844 rows × 1 columns

```
y
```

```
0       neg
1       neg
2       neg
3       neg
4       neg
       ...
1839    pos
1840    neg
1841    neg
1842    neg
1843    neg
Name: label, Length: 1844, dtype: object
```

Encode categorical labels (text labels) into numerical values. The encoder will determine the categories automatically from the data and store them in the categories attribute.

Transfrom the data will return a dense array of shape with the encoded values. The number of categories equal the number of columns.

```
from sklearn.preprocessing import LabelEncoder

encoder = LabelEncoder()

y = encoder.fit_transform(y)
```

```
y
```

```
array([0, 0, 0, ..., 0, 0, 0])
```

Split the dataset into 80% for training and 20% for testing.

```
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)
```

Transform text data in both training and test sets into TF-IDF (Term Frequency-Inverse Document Frequency) vectors.

```
from sklearn.feature_extraction.text import TfidfVectorizer
tfidf = TfidfVectorizer()
```

```
X_train_tfidf = tfidf.fit_transform(X_train['corpus']).toarray()
X_test_tfidf = tfidf.transform(X_test['corpus'])
```

Choose relevant metrics for model evaluation (Accuracy Score, Confusion Matrix).

Choose some popular machine learning algorithms for classification (Random Forest, Decision Tree, Multinomial Naive Bayes).

```
from sklearn.metrics import accuracy_score,confusion_matrix
from sklearn.ensemble import RandomForestClassifier
from sklearn.tree import DecisionTreeClassifier
from sklearn.naive_bayes import MultinomialNB
```

K-Fold Cross Validation is a standard technique for estimating the performance of a machine learning algorithm on a dataset.

In this case, K = 5, it means, in the given dataset and we are splitting into 6 folds and running the Train and Test. During each run, one fold is considered for testing and the rest are for training and moving on with iterations.

In which each data point is used, once in the hold-out set and K-1 in Training. So, during the full iteration at least once, one fold will be used for testing and the rest for training.

In each iterations, we get an accuracy score. Then we sum them and find the mean.

Using K-Fold to estimate above models:

- Define a K-Fold object with the specific number of folds, shuffle option and random state.
- Loop through each model in the models list and perform cross validation using *cross_val_score* function, which returns an array of scores for each fold.
- Store the model name, fold index and score in the *entries* list.
- Convert the entries list into a DataFrame with three columns *model_name*, *fold_id*, *accuracy_score*.
- If plot_results is True, plot a boxplot of the accuracy scores for each model, showing the mean and outliers.
- Group the DataFrame by model name, then calculate the mean and standard deviation of the accuracy scores.
- Concatenate the mean and standard deviation into a new DataFrame called *baseline_results*.
- Sort the *baseline_results* by mean in descending order.
- Return the *baseline_results* DataFrame.

```python
from sklearn.model_selection import KFold, cross_val_score

seed = 1000
def generate_baseline_results(models, X, y, metrics, cv=5, plot_results=False):
    # define k-fold:
    kfold = KFold(n_splits=cv, shuffle=True, random_state=seed)
    entries = []
    for model in models:
        model_name = model.__class__.__name__
        scores = cross_val_score(model, X, y, scoring=metrics, cv=kfold)
        for fold_idx, score in enumerate(scores):
            entries.append((model_name, fold_idx, score))

    cv_df = pd.DataFrame(entries, columns=['model_name', 'fold_id', 'accuracy_score'])

    if plot_results:
        sns.boxplot(x='model_name', y='accuracy_score', data=cv_df, color='lightblue', showmeans=True)
        plt.title("Boxplot of Base-Line Model Accuracy using 5-fold cross-validation")
        plt.xticks(rotation=45)
        plt.show()


    mean = cv_df.groupby('model_name')['accuracy_score'].mean()
    std = cv_df.groupby('model_name')['accuracy_score'].std()

    baseline_results = pd.concat([mean, std], axis=1)
    baseline_results.columns = ['Mean', 'Standard Deviation']


    baseline_results.sort_values(by='Mean', ascending=False, inplace=True)

    return baseline_results

models = [
   DecisionTreeClassifier(),
   RandomForestClassifier(),
   MultinomialNB()
]

baseline_results = generate_baseline_results(models, X_train_tfidf, y_train, metrics='accuracy', cv=5, plot_results=False)
print(baseline_results)
```

	Mean	Standard Deviation
model_name		
RandomForestClassifier	0.917966	0.009406
MultinomialNB	0.907119	0.013041
DecisionTreeClassifier	0.885424	0.013216

Find the optimal hyperparameter configuration for a Random Forest Classifier model, aiming to improve its performance on a specific classification task.

```
from sklearn.model_selection import GridSearchCV


rf = RandomForestClassifier()


param_grid = {
    'n_estimators': [10, 50, 100, 200],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}


grid_search = GridSearchCV(estimator=rf, param_grid=param_grid, cv=5, scoring='accuracy', n_jobs=-1)


grid_search.fit(X_train_tfidf, y_train)


print("Best Parameters: ", grid_search.best_params_)


best_model = grid_search.best_estimator_
```

```
Best Parameters:  {'max_depth': None, 'min_samples_leaf': 1, 'min_samples_split': 2, 'n_estimators': 200}
```

Train a previously identified best model (Decision Tree Classifier) on the training data and evaluate its accuracy on the test data.

```
best_model.fit(X_train_tfidf,y_train)
y_pred = best_model.predict(X_test_tfidf)

accuracy_score(y_test,y_pred)
```

```
0.924119241192412
```

Display Confusion Matrix on the testing data.

```
confusion_matrix(y_test,y_pred)
```

```
array([[332,  11],
       [ 17,   9]])
```

5. Web Demo

Sentiment Analysis

Analyze Text

Text here:

Facebook is fantastic! I use it regularly and have learned so much valuable information from it.

Neg: `0.0`

Neu: `0.64`

Pos: `0.36`

Clean Text:

Facebook is fantastic! I use it regularly and have learned so much valuable information from it.

facebook fantastic use regularly learned much valuable information