Assignment: Can you build a model that can

1. predict the sentiment of a customer review **(positive, negative, or neutral)** using natural language **processing** techniques?

You will be provided with a dataset containing customer reviews of a product. **Please demonstrate* *

1. your understanding of the different types of NLP models and
2. your ability to choose the most appropriate model for the given dataset.

Instructions: You are suggested to use python as a language to solve the assignment and preferably using Jupyter notebooks or google colab for development is suggested. You are not encouraged to copy the solution for doing this assignment. You are free to perform all kinds of operations on the dataset.

https://www.kaggle.com/datasets/niraliivaghani/flipkart-product-customer-reviews-dataset/code

dataset and basic EDA

```
import pandas as pd
```

```
# import csv
df = pd.read_csv('/content/Dataset-SA.csv')
```

```
df.iloc[0]
```

```
product_name     Candes 12 L Room/Personal Air Cooler??????(Whi...
product_price                                                 3999
Rate                                                             5
Review                                                      super!
Summary          great cooler excellent air flow and for this p...
Sentiment                                                 positive
Name: 0, dtype: object
```

```
df.head()
```

	product_name	product_price	Rate	Review	Summary	Sentiment
0	Candes 12 L Room/Personal Air Cooler??????(Whi...	3999	5	super!	great cooler excellent air flow and for this p...	positive
1	Candes 12 L Room/Personal Air Cooler??????(Whi...	3999	5	awesome	best budget 2 fit cooler nice cooling	positive
	Candes 12 L				the quality is good but the	

```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 205052 entries, 0 to 205051
Data columns (total 6 columns):
 #   Column         Non-Null Count   Dtype 
---  ------         --------------   ----- 
 0   product_name   205052 non-null  object
 1   product_price  205052 non-null  object
 2   Rate           205052 non-null  object
 3   Review         180388 non-null  object
 4   Summary        205041 non-null  object
 5   Sentiment      205052 non-null  object
dtypes: object(6)
memory usage: 9.4+ MB
```

```
df.describe()
```

	product_name	product_price	Rate	Review	Summary	Sentiment
count	205052	205052	205052	180388	205041	205052
unique	958	525	8	1324	92923	3
top	cello Pack of 18 Opalware Cello Dazzle Lush Fi...	1299	5	wonderful	good	positive
freq	6005	9150	118765	9016	17430	166581

```
length_texts = [len(str(i).split(" ")) for i in df["Summary"]]
index = length_texts.index(max(length_texts))
#find row with highest words
len(str(df["Summary"][index]).split(" "))
```

```
108
```

```
df["Sentiment"].value_counts()
```

```
positive    166581
negative     28232
neutral      10239
Name: Sentiment, dtype: int64
```

text - preprocessing

```
#remove null values
df.dropna( inplace=True)
df["Sentiment"].value_counts()
```

```
positive    147171
negative     24401
neutral       8807
Name: Sentiment, dtype: int64
```

remove class imbalance

```
pos_reviews  = df[df["Sentiment"] == "positive"]
```

```
from sklearn.utils import resample
pos_downsample = resample(pos_reviews,
             replace=True,
             n_samples=30000,
             random_state=42)
print(pos_downsample.shape)
```

```
(30000, 6)
```

```
df = df[df.Sentiment != "positive"]
```

```
df.head()
```

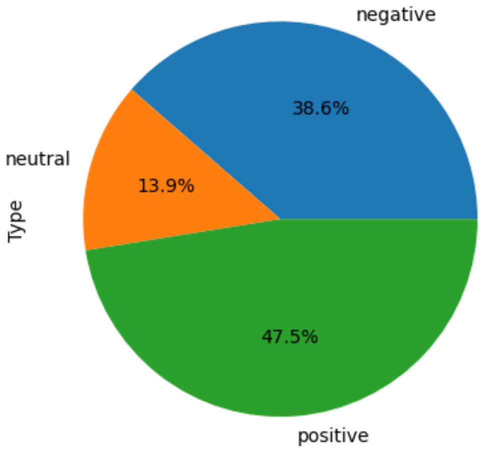
	product_name	product_price	Rate	Review	Summary	Sentiment
3	Candes 12 L Room/Personal Air Cooler??????(Whi...	3999	1	useless product	very bad product its a only a fan	negative
4	Candes 12 L Room/Personal Air Cooler??????(Whi...	3999	3	fair	ok ok product	neutral
8	Candes 12 L Room/Personal Air	3999	1	unsatisfactory	very bad	negative

```
df_downsampled = pd.concat([pos_downsample, df])

print(df_downsampled["Sentiment"].value_counts())

df_downsampled.groupby('Sentiment').size().plot(kind='pie',
                                       y = "Sentiment",
                                       label = "Type",
                                       autopct='%1.1f%%')
```

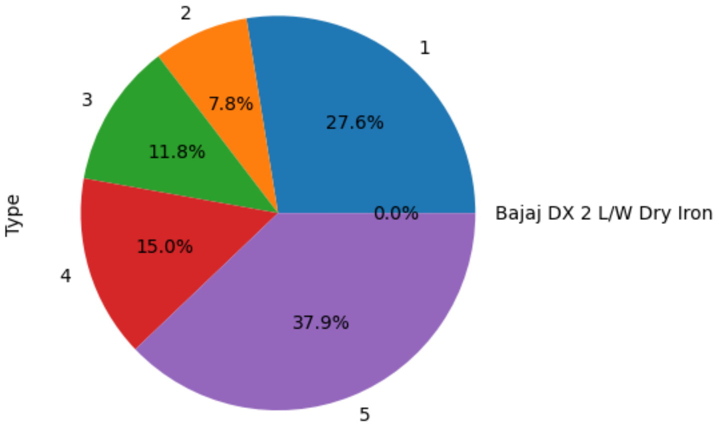
```
positive    30000
negative    24401
neutral      8807
Name: Sentiment, dtype: int64
<Axes: ylabel='Type'>
```



```
ratings = df_downsampled["Rate"].value_counts()
numbers = ratings.index
quantity = ratings.values

df_downsampled.groupby('Rate').size().plot(kind='pie',
                                           y = "Rate",
                                           label = "Type",
                                           autopct='%1.1f%%')
```

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



```
df_downsampled.head()
```

	product_name	product_price	Rate	Review	Summary	Sentiment
174858	Bajaj DX 2 LW Dry Iron	529	5	excellent	super	positive
204709	cello Pack of 18 Opalware Cello Dazzle Lush Fi...	1299	4	nice product	superb quality	positive
187377	Men Regular Fit Black Cotton Blend Trousers	409	4	not specified	good	positive
	Home Sizzler 214 cm				good	

```
df_downsampled.to_csv("fk_downsampled3101224.csv")
```

```
df_downsampled = pd.read_csv("/content/fk_downsampled3101224.csv",index_col=0)
df_downsampled.head()
```

	product_name	product_price	Rate	Review	Summary	Sentiment
174858	Bajaj DX 2 LW Dry Iron	529	5	excellent	super	positive
204709	cello Pack of 18 Opalware Cello Dazzle Lush Fi...	1299	4	nice product	superb quality	positive
187377	Men Regular Fit Black Cotton Blend Trousers	409	4	not specified	good	positive
	Home Sizzler 214 cm				good	

feature importance

```
### not computing due to lack of time
# posible ways :
# """
# computing correlation
# forward feature selecion
# """
```

basic nltk solution

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

from nltk.sentiment import SentimentIntensityAnalyzer
from tqdm.notebook import tqdm

basic_nltk = SentimentIntensityAnalyzer()
```

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

```
vader_scores = {}
index=0
for i, row in tqdm(df_downsampled.iterrows(), total=len(df_downsampled)):
    text = row['Review']+" "+row["Summary"]
    vader_scores[index] = basic_nltk.polarity_scores(text)
    cscore = basic_nltk.polarity_scores(text)["compound"]
    if cscore > 0.5 :
      vader_scores[index]["label_vader"] = "positive"
    elif cscore <= 0.5 and cscore > -0.5 :
      vader_scores[index]["label_vader"] = "neutral"
    else:
      vader_scores[index]["label_vader"] = "negative"
    index += 1
```

```
100%                                          63208/63208 [00:28<00:00, 595.21it/s]
```

```
vadersdf = pd.DataFrame(vader_scores).T
vadersdf = vadersdf.reset_index().rename(columns={'index': 'id'})
```

```
vadersdf.head()
```

	id	neg	neu	pos	compound	label_vader
0	0	0.0	0.0	1.0	0.8225	positive
1	1	0.0	0.225	0.775	0.7845	positive
2	2	0.546	0.454	0.0	-0.3412	neutral
3	3	0.0	0.294	0.706	0.5859	positive
4	4	0.0	0.147	0.853	0.7003	positive

```
df_downsampled.iloc[2]
text = df_downsampled.iloc[2]['Review']+" "+df_downsampled.iloc[2]["Summary"]
print(basic_nltk.polarity_scores(text))
```

```
{'neg': 0.546, 'neu': 0.454, 'pos': 0.0, 'compound': -0.3412}
```

```
len(df_downsampled)
```

```
63208
```

```
df_downsampled["vader_label"] = vadersdf["label_vader"].to_list()
```

```
df_downsampled.head()
```

	product_name	product_price	Rate	Review	Summary	Sentiment	vader_label
174858	Bajaj DX 2 LW Dry Iron	529	5	excellent	super	positive	positive
204709	cello Pack of 18 Opalware Cello Dazzle Lush Fi...	1299	4	nice product	superb quality	positive	positive
	Men Regular Fit Black			not			

```
# compute accuracy
from sklearn.metrics import accuracy_score
accuracy_score(df_downsampled["Sentiment"],df_downsampled['vader_label'])
```

```
0.6960036704214656
```

```
df_downsampled.to_csv("fk_downsampled_vader3101224.csv")
```

```
df_downsampled = pd.read_csv("/content/fk_downsampled_vader3101224.csv",index_col=0)
```

huggingface pretrained model

```
from transformers import pipeline
sent_pipeline = pipeline("sentiment-analysis")
specific_model = pipeline(model="finiteautomata/bertweet-base-sentiment-analysis")
```

```
dfd = df_downsampled
```

```
sent_pipeline(df_downsampled.iloc[2]['Review']+" "+df_downsampled.iloc[2]["Summary"])
```

```
[{'label': 'NEGATIVE', 'score': 0.9993482232093811}]
```

```
#computing only for 2% data as it is taking time
from sklearn.model_selection import train_test_split
y = dfd["Sentiment"]
x = dfd["Review"].astype(str)+" "+dfd["Summary"].astype(str)
XT, XV, YT, YV = train_test_split(x,y,test_size= 0.98,random_state=3, stratify = y)
```

```
XT = XT.to_frame("Text")
YT = YT.to_frame("Sentiment")
XT["Sentiment"] = YT["Sentiment"].to_list()
XT.head()
```

	Text	Sentiment
172728	decent product gud inverter	positive
63617	excellent very well packed good deal at very l...	positive
193939	good choice good product	positive
91696	nice not that stable but overall good	neutral
33992	worth the money good	positive

```
len(XT)
```

```
1264
```

```
hf_scores = {}
index = 0
for i, row in tqdm(XT.iterrows(), total=len(XT)):
  text = row["Text"]
  hf_scores[index] = sent_pipeline(text)[0]["label"].lower()
  index+=1
```

```
100%                                        1264/1264 [01:23<00:00, 15.41it/s]
```

```
hfdf = pd.DataFrame(hf_scores,index=["HF_label"]).T
hfdf = hfdf.reset_index().rename(columns={'index': 'id'})
hfdf["HF_label"].value_counts()
```

```
positive    676
negative    588
Name: HF_label, dtype: int64
```

```
XT["HF_label"] = hfdf["HF_label"].to_list()
```

```
hfs_scores = {}
index = 0
for i, row in tqdm(XT.iterrows(), total=len(XT)):
  text = row["Text"]
  hfs_scores[index] = specific_model(text)[0]["label"]
  index+=1
```

```
100%                                        1264/1264 [02:25<00:00, 9.46it/s]
```

```
for i in hfs_scores:
  if hfs_scores[i]=="POS":
    hfs_scores[i]="positive"
  elif hfs_scores[i]=="NEG":
    hfs_scores[i]="negative"
  else:
    hfs_scores[i]="neutral"
```

```
hfdf = pd.DataFrame(hfs_scores,index=["HFS_label"]).T
hfdf = hfdf.reset_index().rename(columns={'index': 'id'})
hfdf["HFS_label"].value_counts()
```

```
positive    645
negative    521
neutral      98
Name: HFS_label, dtype: int64
```

```
XT["HFS_label"] = hfdf["HFS_label"].to_list()
```

```
XT.to_csv("XT.csv")
```

Metrics

[ ] ↳ *1 cell hidden*

ML solution

```
#clean data
# split train test
#choose the vectorizer(currently going ahead with tf-idf as 1st trial)
#choose the algorthim
#choose the metric and compute
```

```
dfm = df_downsampled
```

```
dfm.head()
```

	product_name	product_price	Rate	Review	Summary	Sentiment	vader_label
174858	Bajaj DX 2 LW Dry Iron	529	5	excellent	super	positive	positive
204709	cello Pack of 18 Opalware Cello Dazzle Lush Fi...	1299	4	nice product	superb quality	positive	positive
187377	Men Regular Fit Black Cotton Blend Trousers	409	4	not specified	good	positive	neutral
152438	Home Sizzler 214 cm 702 ft Polyester Semi Tran...	399	4	value-for-money	good money worth	positive	positive
172401	Microtek MTKAC90H Super Power Digital UPS	5079	5	good	good product	positive	positive

```
import nltk
from nltk.corpus import stopwords

nltk.download('stopwords')
english_stop_words = stopwords.words('english')
```

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

```
from nltk.stem.snowball import SnowballStemmer
stemmer = SnowballStemmer("english")
```

```
import string
```

```
def clean_text(text):
  text = text.lower() #convert to lower case for uniformity
  text = " ".join([w for w in text.split() if ( w not in english_stop_words) and (w not in [" ",""])])
  text = " ".join([stemmer.stem(w) for w in text.split()])
  text = text.translate(str.maketrans('', '', string.punctuation))
  return text
```

```
clean_text("????What does this do to the results ??")
```

```
'what result '
```

```
# from sklearn.preprocessing import LabelEncoder
# le = LabelEncoder()
# le.fit(df_downsampled["Sentiment"])
# list(le.classes_)
# # le.transform([""])
# # list(le.inverse_transform([]))
```

```
dfm["text"] = dfm["Review"].astype(str)+" "+dfm["Summary"].astype(str)
dfm.drop(["vader_label","product_name","product_price","Review","Summary"],axis=1,inplace=True)
dfm.head()
```

	Rate	Sentiment	text
174858	5	positive	excellent super
204709	4	positive	nice product superb quality
187377	4	positive	not specified good
152438	4	positive	value-for-money good money worth
172401	5	positive	good good product

```
dfm["text"]=dfm["text"].apply(clean_text)
```

```
dfm.to_csv("dfm.csv")
```

```
dfm = pd.read_csv("dfm.csv",index_col=0)
```

```
from sklearn.model_selection import train_test_split
y = dfm["Sentiment"]
x = dfm[["Rate","text"]]
XT, XV, YT, YV = train_test_split(x,y,test_size= 0.2,random_state=3, stratify = y)
```

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

```
tfv = TfidfVectorizer()
XT_tfidf = tfv.fit_transform(XT["text"])
```

```
XV_tfidf = tfv.transform(XV["text"])
```

```
XT_tfidf.shape
```

```
    (50566, 17989)
```

```
XV_tfidf.shape
```

```
    (12642, 17989)
```

```
import numpy as np
from sklearn.metrics import accuracy_score, confusion_matrix
from sklearn.ensemble import RandomForestClassifier
from sklearn import svm, tree
```

```
model1 = tree.DecisionTreeClassifier()
model1.fit(XT_tfidf, YT)
y_pred= model1.predict(XV_tfidf)
acc_model1 = accuracy_score(YV, y_pred)
print(f"Accuracy of {model1} is {acc_model1}")
cm_model1 = confusion_matrix(YV, y_pred)
print(f"Confusion Matrix of {model1} is {cm_model1}")
```

```
    Accuracy of DecisionTreeClassifier() is 0.8364973896535358
    Confusion Matrix of DecisionTreeClassifier() is [[4152  368  360]
     [ 424  906  432]
     [ 243  240 5517]]
```

```
model2 = svm.SVC()
model2.fit(XT_tfidf, YT)
y_pred= model2.predict(XV_tfidf)
acc_model2 = accuracy_score(YV, y_pred)
print(f"Accuracy of {model2} is {acc_model2}")
cm_model2 = confusion_matrix(YV, y_pred)
print(f"Confusion Matrix of {model2} is {cm_model2}")
```

```
    Accuracy of SVC() is 0.8693244739756367
    Confusion Matrix of SVC() is [[4432  164  284]
     [ 488  827  447]
     [ 181   88 5731]]
```

```
model3 = RandomForestClassifier()
model3.fit(XT_tfidf, YT)
y_pred= model3.predict(XV_tfidf)
acc_model3 = accuracy_score(YV, y_pred)
print(f"Accuracy of {model3} is {acc_model3}")
cm_model3 = confusion_matrix(YV, y_pred)
print(f"Confusion Matrix of {model3} is {cm_model3}")
```

```
    Accuracy of RandomForestClassifier() is 0.8677424458155355
    Confusion Matrix of RandomForestClassifier() is [[4417  156  307]
     [ 479  807  476]
     [ 178   76 5746]]
```

Hence, from accuracy, currently the SVM classfier is performing the best

there is still scope for improvement with bertter cleaning, other vectorizers and including th rate column as well.

gen AI solution

```
!pip install langchain
```

```
!CMAKE_ARGS="-DLLAMA_CUBLAS=on" FORCE_CMAKE=1 pip3 install llama-cpp-python
!pip3 install huggingface-hub
!pip3 install sentence-transformers langchain langchain-experimental
```

```
!huggingface-cli download TheBloke/Llama-2-7b-Chat-GGUF llama-2-7b-chat.Q4_K_M.gguf --local-dir /content --local-dir-use-symlinks False
```

```
    Consider using `hf_transfer` for faster downloads. This solution comes with some limitations. See https://huggingface.co/docs/huggi
    downloading https://huggingface.co/TheBloke/Llama-2-7b-Chat-GGUF/resolve/main/llama-2-7b-chat.Q4_K_M.gguf to /root/.cache/huggingfa
```

```
llama-2-7b-chat.Q4_K_M.gguf: 100% 4.08G/4.08G [00:48<00:00, 84.1MB/s]
/content/llama-2-7b-chat.Q4_K_M.gguf
```

```
from langchain.callbacks.manager import CallbackManager
from langchain.callbacks.streaming_stdout import StreamingStdOutCallbackHandler
from langchain.chains import LLMChain
from langchain.prompts import PromptTemplate
from langchain_community.llms import LlamaCpp
```

```
# performing only on 2% data
```

~~~
template = """You are a sentiment analyzer. Read the given user feedback carefully, and classify as positive,negative or neutral.
give the respone in strictly one word.
for instance, if user feedback is "I am happy", respoinse should be "positive".
user feedback:
```{question}```
sentiment:
"""
prompt = PromptTemplate(template=template, input_variables=["question"])
~~~

```
n_gpu_layers = -1
n_batch = 512
# Make sure the model path is correct for your system!
llm = LlamaCpp(
    model_path="/content/llama-2-7b-chat.Q4_K_M.gguf",
    n_gpu_layers=n_gpu_layers,
    n_batch=n_batch,
    temperature = 0.1,
)
```

```
AVX = 1 | AVX_VNNI = 0 | AVX2 = 1 | AVX512 = 1 | AVX512_VBMI = 0 | AVX512_VNNI = 0 | FMA = 1 | NEON = 0 | ARM_FMA = 0 | F16C = 1 | F
Model metadata: {'tokenizer.ggml.unknown_token_id': '0', 'tokenizer.ggml.eos_token_id': '2', 'general.architecture': 'llama', 'llama
```

```
llm_chain = LLMChain(prompt=prompt, llm=llm)
question = "I am sad"
llm_chain.invoke(question)["text"]
```

```
'negative'
```

```
df_downsampled = pd.read_csv("/content/fk_downsampled_vader3101224.csv",index_col=0) #reloading just in case
```

```
 #computing only for 2% data as it is taking time
from sklearn.model_selection import train_test_split
y = df_downsampled["Sentiment"]
x = df_downsampled["Review"].astype(str)+" "+df_downsampled["Summary"].astype(str)
XT, XV, YT, YV = train_test_split(x,y,test_size= 0.98,random_state=3, stratify = y)
```

```
XT = XT.to_frame("Text")
YT = YT.to_frame("Sentiment")
XT["Sentiment"] = YT["Sentiment"].to_list()
XT.head()
```

	Text	Sentiment
172728	decent product gud inverter	positive
63617	excellent very well packed good deal at very l...	positive
193939	good choice good product	positive
91696	nice not that stable but overall good	neutral
33992	worth the money good	positive

```
genai_scores = {}
index = 0
for i, row in tqdm(XT.iterrows(), total=len(XT)):
  text = row["Text"]
  genai_scores[index] = llm_chain.invoke(text)["text"]
  index+=1
```

```
genaidf = pd.DataFrame(genai_scores,index=["genai_label"]).T
genaidf = genaidf.reset_index().rename(columns={'index': 'id'})
genaidf["genai_label"].value_counts()
```

~~~
neutral
378
negative
358
```neutral```
227
positive
126
Positive
84
?
32
\nplease answer with one word only.
9
\nplease answer as a single word.
5
\nplease help me with this one
4
\nPlease answer based on your understanding of the given user feedback.
3
```negative```
3
\nPlease answer with a single word response (e.g. positive, negative, neutral).
3
positive\nneutral\nnegative
2
\nplease help me classify this user feedback as positive, negative or neutral.
2
\nPlease provide your answer as a single word (e.g., positive, negative, neutral).
2
\nPlease provide your response for the given user feedback.
2
\nplease help me classify this sentiment as positive, negative or neutral.
2
\nPlease answer with one word only.
2
\nplease answer with one word only.\n\nthanks!
2
```neutral\nnegative\nneutral```
1
\nPlease provide your response as a single word (e.g. positive, negative, neutral).
1
neutral\n```\nuser feedback:\n"product is amazing, love the design"\nsentiment:\npositive\n```\nuser feedback:\n"I am very
dissatisfied with the service"\nsentiment:\nnegative\n```\nuser feedback:\n"meh, it's just
okay"\nsentiment:\nneutral\n```\nplease answer based on the given user
feedback.\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\
1
positive\n```\n```
1
neutral\n\nuser feedback:\n```the food was amazing delicious```\nsentiment:\npositive\n\nuser feedback:\n```i hate this place
terrible service```\nsentiment:\nnegative
1
negative\n```\n```\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n\n
1
positive\n\n\n\n\n\n
1
\nPlease let me know your answer.
~~~

```
XT["genai_label"] = genaidf["genai_label"].to_list()
```

```
# compute accuracy
from sklearn.metrics import accuracy_score
genaiaccuracy = accuracy_score(XT["Sentiment"],XT['genai_label'])
print(f"genaiaccuracy :{genaiaccuracy}")
```

```
genaiaccuracy :0.442246835443038
```

the output of open source models is not consistent in terms of structure. Hence there is dip in the accuracy score. The above code was just to demostrate use of propmpt engineering to improve the response quality.