Intro_to_Natural_Language_Processing

November 10, 2023

Natural Language Processing, or NLP, is a field at the intersection of computer science, artificial intelligence, and linguistics. Its goal is to enable computers to understand, interpret, generate, and respond to human language in a valuable way. This understanding could range from simple tasks (like identifying the language of the text) to complex ones (like sentiment analysis, machine translation, and summarization).

1 What will you gain from this assignment?

- **Practical Skills**: You'll gain hands-on experience working with text data — the largest data type in the world today

- **Analytical Thinking**: You'll learn how to approach language as a data scientist, breaking down sentences into tokens, extracting meaningful features, and turning text into data that machines can understand

- **Understanding of Core Concepts**: NLP is built on key principles of linguistics, computer science, and machine learning. Through this assignment, you'll get a sneak-peek into these fascinating areas

- **Tool Familiarity**: This assignment will familiarize you with essential libraries for NLP. These tools are widely used in academia and industry, making this knowledge incredibly transferable

2 Note

Both the test and the Jupiter notebook are required parts of this assignment

3 Setup

Run the following code cells for the correct execution of the code. Also it will connect your Google Drive with the temporary storage connected with this nothebook

```
[ ]: !pip install nltk
     !pip install pandas
     !pip install gensim
     !pip install wordcloud
     !pip install matplotlib
     !pip install transformers
```

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/Users/liuyucheng/anaconda3/envs/py38/lib/python3.8/site-packages (from
requests->transformers) (2023.7.22)
```

```python
import nltk
import string
import random
import warnings

import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

from nltk.corpus import wordnet
from wordcloud import WordCloud
from gensim.models import Word2Vec
from gensim.models import KeyedVectors
from nltk.tokenize import sent_tokenize
from sklearn.metrics import accuracy_score
from sklearn.naive_bayes import MultinomialNB
from sklearn.feature_extraction.text import CountVectorizer
from transformers import BartTokenizer, BartForConditionalGeneration, pipeline
```

```
warnings.filterwarnings('ignore')
nltk.download('wordnet')
nltk.download('punkt')
```

/Users/liuyucheng/anaconda3/envs/py38/lib/python3.8/site-
packages/tqdm/auto.py:21: TqdmWarning: IProgress not found. Please update
jupyter and ipywidgets. See
https://ipywidgets.readthedocs.io/en/stable/user_install.html
  from .autonotebook import tqdm as notebook_tqdm
[nltk_data] Downloading package wordnet to
[nltk_data]   /Users/liuyucheng/nltk_data…
[nltk_data]   Package wordnet is already up-to-date!
[nltk_data] Downloading package punkt to
[nltk_data]   /Users/liuyucheng/nltk_data…
[nltk_data]   Package punkt is already up-to-date!

[ ]: True

Upload text.txt to Colab and check if path to the file is correct:

```
data_path = "/Users/liuyucheng/Desktop/
  ↪Introduction_to_Computational_Thinking_and_Data_Science/Dataset/Ivanhoe.txt"
with open(data_path, 'r') as f:
    lines = f.readlines()
    for i in range(min(10, len(lines))):
        print(lines[i].strip())
```

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… then everything is correct!

Run the last cell before you will be ready to solve some real NLP problems!

```
[ ]: def read_document(path):
         with open(path, 'r', encoding='utf-8') as file:
             text = file.read()
         return text


     text = read_document(data_path)
```

4 Tasks

4.1 Task 1 (7 points)

Textual data can often be overwhelming due to its volume and complexity. Visualization techniques, such as generating a word cloud, provide a quick and insightful way to understand the essential features of a text document. It is a powerful tool for exploratory data analysis, summarizing large chunks of text data in a visually appealing and interpretable manner

Run the following code cell to understand how word cloud looks like

```
[ ]: wordcloud = WordCloud(background_color = 'white', width = 800, height = 400,␣
      ↪max_words = 100, contour_width = 3, contour_color = 'steelblue')
     wordcloud.generate(text)

     plt.figure(figsize = (10, 10))
     plt.imshow(wordcloud, interpolation ='bilinear')
     plt.axis("off")
     plt.show()
```


Question 1: You've just generated and seen a word cloud based on the text document. Now, let's delve into what a word cloud represents and your impressions of this particular one. In your own

words, explain what a word cloud is and what it is commonly used for.

Answer : In my point of view, the word clou means the frequency of the word. The bigger the word in the picture, the more frequently the qord shows in the text. As far as I am concerned, this technology is usually uased in text analysis. For example, when we are going to analyze the theme in a book or passage, we can use this technology to find the top mostly words showing in the passage. We can more easily to catch the main idea and theme of a passage. In this picture, it is the word of 'said' and 'will' leave the most impression with me. It reflects the one of the features of email. In the email, we usualy use the past tense and future tense in the email.

4.2 Task 2 (7 points)

Understanding the frequency distribution of words in a document provides key insights into its thematic focus and content. It can serve as a rudimentary form of text summarization and aids in grasping the essence of the document.

This task is particularly important because word frequency counts are often a starting point for more advanced NLP techniques, such as text classification, clustering, or topic modeling

Output the first 10 frequent words from the text

```python
words = text.split()
word_counts = {}

N = 10

for word in words:
    if word in word_counts:
        word_counts[word] += 1
    else:
        word_counts[word] = 1

sorted_word_counts = sorted(word_counts.items(), key = lambda x: x[1], reverse
 = True)[ : N]

print("The  most frequent words are:")
for word, freq in sorted_word_counts:
    print(f"{word}: {freq}")
```

```
The  most frequent words are:
the: 12942
of: 8129
and: 5632
to: 5421
a: 3544
in: 2751
his: 2619
with: 1817
as: 1670
that: 1666
```

The result is pretty surprising, isn't it?

The word cloud automatically filters out "stop words" like *the*, *a*, *in*, and so on. These are common words that appear frequently in almost all text but are usually considered to be of little value in text analysis because they don't carry significant meaning. Therefore, the word cloud focuses on displaying the more "interesting" or unique words in the text.

On the other hand, when we count word frequencies manually without filtering out these stop words, they naturally rise to the top as the most frequent words. So don't worry if the two don't match; it's all about what is being filtered out!

Question 2: Given that the most frequent words are often stop words that might not carry much individual meaning, what other methods could we use to better understand the thematic content of the text? How might we modify our approach to get a clearer picture of the document's main topics or sentiments?

Answer:: In my opinion, the word like 'on' and 'an' are also a kind of stop words without any specific meanings. There are several methods to filter the stop wods out of the list. On the one hand, we can build up a word list in the program. When we are goin to analyze the text, if program find the word in the list, it can just ignore it. There are many pulished stop word lists online to download. Besides, you can use TF-IDF[1] algorithm to filter the stop words out of the text.

Reference: [1] https://en.wikipedia.org/wiki/Tf%E2%80%93idf

4.3 Task 3 (7 points)

In previous tasks, we focused on visualizing and identifying the most frequent words in the text. Now let's shift our focus to a single, specific word. Your task is to find all occurrences of a word *Ivanhoe* in the text

```
words = text.split()
target_word = 'Ivanhoe' # YOUR CODE
target_word_frequency = 0
for word in words:
    if word == target_word:
        target_word_frequency += 1

print(f"The word '{target_word}' appears {target_word_frequency} times in the
 text.")
```

The word 'Ivanhoe' appears 55 times in the text.

Question 3: Now that you know how many times the word *Ivanhoe* appears in the text, what might be the significance or role of this character in the story? How does the frequency of this word correlate with its importance in the text? Would you expect this word to appear more or less frequently, and why?

answer: I suppose that the more frequently this role showing up in this text, the more important this role is. Since, a role who frequently shoing in the role may have more chances to influence the development of the story. The higher frequency usually means the role may more likely to be the main role in this story. We need to more consider the sentences or words about him when doing the analysis. The frequency of this name depends on different tasks. If we need to do the analysis

about this character, we hope this role shows up as more as possible so that we have more materials to analyze. If it is the analysis about a=other characters, I don't think it is great for this character to show up for too many times since If the name of this character appears too frequently, it will interfere with our analysis of the text.

4.4   Task 4 (7 points)

Text data is inherently categorical and must be converted into numerical format to be utilized by machine learning algorithms. One simple yet powerful method to achieve this is binary vectorization. In this task, you will get hands-on experience with this concept, which will lay the groundwork for more complex natural language processing tasks you'll encounter later.

Convert a set of sentences into binary vectors using Python. Each position in the vector corresponds to a unique word in the vocabulary created from the selected sentences. A position in the vector will be marked as 1 if the corresponding word is present in the sentence, and 0 otherwise.

Your task is to fill the gaps in the code cell with proper values

```
[ ]: sentences_all = text.split('. ')

     random_sentences = random.sample(sentences_all, 10)
     for i in range(len(random_sentences)):
       print("\nSENTENCE # ", i, ",", random_sentences[i], "\n")

     vocabulary = set()
     # Tokenize sentences and build vocabulary
     tokenized_sentences = []
     for sentence in random_sentences:
         words = sentence.lower().split()
         tokenized_sentences.append(words)
         for word in words:
             vocabulary.add(word) # REPLACE ___ WITH YOUR CODE

     vocabulary_list = list(vocabulary)

     for sentence in tokenized_sentences:
         for vocab_word in vocabulary_list:
             print(vocab_word)

     # Create binary vectors
     binary_vectors = []
     for sentence in tokenized_sentences:
         vec = []
         for vocab_word in vocabulary_list:
             if vocab_word in sentence:
                 vec.append(1) # REPLACE ___ WITH YOUR CODE
             else:
                 vec.append(0) # REPLACE ___ WITH YOUR CODE
         binary_vectors.append(vec)
```

```python
print("Binary Vectors:")
for vec in binary_vectors:
    print(vec)
```

SENTENCE # 0 , I am more intent on punishing that villain Abbot.
He shall hang on the top of this Castle of Coningsburgh, in his cope
and stole; and if the stairs be too strait to admit his fat carcass, I
will have him craned up from without."

"But, my son," said Edith, "consider his sacred office."

"Consider my three days' fast," replied Athelstane; "I will have their
blood every one of them

SENTENCE # 1 , But why, oh why, noble Prince, will you thus vex
the hearts of your faithful servants, and expose your life by lonely
journeys and rash adventures, as if it were of no more value than that
of a mere knight-errant, who has no interest on earth but what lance
and sword may procure him?"

"And Richard Plantagenet," said the King, "desires no more fame than
his good lance and sword may acquire him-and Richard Plantagenet is
prouder of achieving an adventure, with only his good sword, and his
good arm to speed, than if he led to battle a host of an hundred
thousand armed men."

"But your kingdom, my Liege," said Ivanhoe, "your kingdom is threatened
with dissolution and civil war-your subjects menaced with every species
of evil, if deprived of their sovereign in some of those dangers which
it is your daily pleasure to incur, and from which you have but this
moment narrowly escaped."

"Ho! ho! my kingdom and my subjects?" answered Richard, impatiently; "I
tell thee, Sir Wilfred, the best of them are most willing to repay my
follies in kind-For example, my very faithful servant, Wilfred of
Ivanhoe, will not obey my positive commands, and yet reads his king a
homily, because he does not walk exactly by his advice

SENTENCE # 2 , Let his wants be ministered to with all care-look to it,
Oswald."

And the steward left the banqueting hall to see the commands of his
patron obeyed.

CHAPTER V

Hath not a Jew eyes? Hath not a Jew hands, organs, dimensions, senses, affections, passions? Fed with the same food, hurt with the same weapons, subject to the same diseases, healed by the same means, warmed and cooled by the same winter and summer, as a Christian is?

MERCHANT OF VENICE

Oswald, returning, whispered into the ear of his master, "It is a Jew, who calls himself Isaac of York; is it fit I should marshall him into the hall?"

"Let Gurth do thine office, Oswald," said Wamba with his usual effrontery; "the swineherd will be a fit usher to the Jew."

"St Mary," said the Abbot, crossing himself, "an unbelieving Jew, and admitted into this presence!"

"A dog Jew," echoed the Templar, "to approach a defender of the Holy Sepulchre?"

"By my faith," said Wamba, "it would seem the Templars love the Jews' inheritance better than they do their company."

"Peace, my worthy guests," said Cedric; "my hospitality must not be bounded by your dislikes

SENTENCE # 3 , What, then, would it avail the reader to know their names, or the evanescent symbols of their martial rank!

Now, however, no whit anticipating the oblivion which awaited their names and feats, the champions advanced through the lists, restraining their fiery steeds, and compelling them to move slowly, while, at the same time, they exhibited their paces, together with the grace and dexterity of the riders

SENTENCE # 4 , The arrow whistled through the air, and lighted within the inner ring of the target, but not exactly in the centre.

"You have not allowed for the wind, Hubert," said his antagonist, bending his bow, "or that had been a better shot."

So saying, and without showing the least anxiety to pause upon his aim, Locksley stept to the appointed station, and shot his arrow as carelessly in appearance as if he had not even looked at the mark

SENTENCE # 5 , She is a sorceress, and must suffer as such."

"She shall not, by Heaven!" said Bois-Guilbert.

"By Heaven, she must and will!" said Malvoisin

SENTENCE # 6 , Let them have change of vestments if they require it, and fire, and water to wash, and wine and ale; and bid the cooks add what they hastily can to our evening meal; and let it be put on the board when those strangers are ready to share it

SENTENCE # 7 , The souls of our pure founders, the spirits of Hugh de Payen and Godfrey de Saint Omer, and of the blessed Seven who first joined in dedicating their lives to the service of the Temple, are disturbed even in the enjoyment of paradise itself

SENTENCE # 8 , Such was the address of each in parrying and striking, that the spectators broke forth into a unanimous and involuntary shout, expressive of their delight and admiration.

But at this moment the party of the Disinherited Knight had the worst; the gigantic arm of Front-de-Bœuf on the one flank, and the ponderous strength of Athelstane on the other, bearing down and dispersing those immediately exposed to them

SENTENCE # 9 , For he that does good, having the unlimited power to do evil, deserves praise not only for the good which he performs, but for the evil which he forbears

presence!"
abbot.
champions
restraining

payen
days'
if
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are
dangers
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pure
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"but
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same
escaped."
is?
worthy
cedric;
oswald."
tell
those
whispered
bid
acquire
board
why,
however,
coningsburgh,
and
dispersing
unlimited
gigantic
more
exactly
himself,
air,
yet
repay
paces,
richard
cooled
craned
speed,
answered
were
ministered
appearance
target,
stept

deprived
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led
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approach
do
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daily
unanimous
narrowly
three
top
heaven!"
in
itself
host
swineherd
left
lonely
such
"desires
isaac
"ho!
mere
thee,
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that
heaven,
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not,
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station,
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incur,
shot."
suffer
impatiently;
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allowed
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merchant
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shout,
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inner
stairs
defender
"your
they
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what
hath
it,
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performs,
of
holy
looked
ring
not
commands,
admiration.
on
inheritance
menaced
york;

seven
water
then,
within
down
admit
hearts
which
fit
earth
office,
wine
civil
rank!
hugh
power
"peace,
means,
prince,
at
servant,
stole;
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better
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oswald,"
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but
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striking,
mary,"
food,
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bending
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templar,
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without."
him?"
fiery
care-look
what,
paradise
be
edith,
usual
calls
service
worst;
all
weapons,
jew."
compelling
abbot,
front-de-bœuf
because
centre.
journeys
our
each

steward
example,
your
omer,
love
unbelieving
party
can
together
add
thus
than
"a
oswald,
she
subjects
when
wants
address
"an
battle
even
company."
ready
them
evanescent
warmed
ho!
involuntary
affections,
put
anticipating
my
dimensions,
pleasure
avail
liege,"
faith,"
him
no
plantagenet,"
"by
faithful
knight-errant,
arm
"my
jew,
"but,

lives
banqueting
wamba
athelstane;
one
servants,
bow,
i
cope
move
some
only
hastily
strength
with
dislikes
locksley
men."
summer,
willing
shall
value
too
first
shot
most
fat
kingdom
eyes?
expose
homily,
dissolution
presence!"
abbot.
champions
restraining
payen
days'
if
whistled
obeyed.
are
dangers
strangers
pure
exposed
"but
jew

same
escaped."
is?
worthy
cedric;
oswald."
tell
those
whispered
bid
acquire
board
why,
however,
coningsburgh,
and
dispersing
unlimited
gigantic
more
exactly
himself,
air,
yet
repay
paces,
richard
cooled
craned
speed,
answered
were
ministered
appearance
target,
stept
deprived
reads
hurt
led
oblivion
approach
do
crossing
daily
unanimous
narrowly
three

top
heaven!"
in
itself
host
swineherd
left
lonely
such
"desires
isaac
"ho!
mere
thee,
names,
that
heaven,
armed
not,
"it
station,
sacred
incur,
shot."
suffer
impatiently;
mark
fed
cooks
"she
to
interest
hang
blessed
wamba,
bearing
"let
saint
hall?"
replied
sword
a
am
advice
diseases,
symbols
achieving
now,

aim,
such."
allowed
hubert,"
merchant
martial
shout,
sorceress,
every
oh
steeds,
adventures,
without
inner
stairs
defender
"your
they
riders
office."
what
hath
it,
hall
performs,
of
holy
looked
ring
not
commands,
admiration.
on
inheritance
menaced
york;
seven
water
then,
within
down
admit
hearts
which
fit
earth
office,
wine

civil
rank!
hugh
power
"peace,
means,
prince,
at
servant,
stole;
king
better
species
an
pause
evil,
lighted
oswald,"
you
time,
but
"i
striking,
mary,"
food,
plantagenet
bending
positive
will!"
templar,
sword,
hospitality
v
admitted
"you
share
punishing
wash,
war-your
"consider
vestments
temple,
slowly,
would
life
fast,"
showing
as

effrontery;
hands,
antagonist,
"the
wilfred
names
for
flank,
organs,
exhibited
"st
evil
other,
obey
has
he
healed
seem
son,"
templars
evening
good,
up
master,
kingdom,
delight
very
fire,
knight
ear
broke
commands
through
who
moment
let
villain
arrow
lists,
wind,
into
immediately
whit
ale;
thousand
senses,
rash
change

godfrey
will
should
dexterity
while,
or
advanced
feats,
enjoyment
lance
de
jew,"
dedicating
know
had
fame
returning,
good
marshall
king,
echoed
must
prouder
noble
subjects?"
does
anxiety
malvoisin
wilfred,
so
gurth
least
bounded
joined
forbears
forth
vex
athelstane
was
reader
hundred
souls
the
"to
"and
blood
by
subject

praise
"or
intent
himself
sepulchre?"
spectators
their
disinherited
parrying
carcass,
meal;
this
dog
adventure,
guests,"
sovereign
said
follies
spirits
kind-for
venice
from
best
usher
carelessly
strait
threatened
upon
bois-guilbert.
founders,
richard,
been
patron
procure
saying,
having
have
is
ivanhoe,
disturbed
grace
appointed
sir
winter
ponderous
castle
passions?
deserves

christian
his
thine
chapter
require
awaited
jews'
see
may
it
walk
expressive
him-and
without."
him?"
fiery
care-look
what,
paradise
be
edith,
usual
calls
service
worst;
all
weapons,
jew."
compelling
abbot,
front-de-bœuf
because
centre.
journeys
our
each
steward
example,
your
omer,
love
unbelieving
party
can
together
add
thus
than

"a
oswald,
she
subjects
when
wants
address
"an
battle
even
company."
ready
them
evanescent
warmed
ho!
involuntary
affections,
put
anticipating
my
dimensions,
pleasure
avail
liege,"
faith,"
him
no
plantagenet,"
"by
faithful
knight-errant,
arm
"my
jew,
"but,
lives
banqueting
wamba
athelstane;
one
servants,
bow,
i
cope
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some
only

hastily
strength
with
dislikes
locksley
men."
summer,
willing
shall
value
too
first
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fat
kingdom
eyes?
expose
homily,
dissolution
Binary Vectors:
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0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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```

```
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[0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 1, 0, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
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```
0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0,
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0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
```

Astonishing result, isn't it? But let's be sure that everything is clear:

In the given output, each `SENTENCE # X` line represents one of the 10 randomly selected sentences from the original text. Following each sentence is its corresponding binary vector, which is a list of zeros and ones. The length of each binary vector is equal to the total number of unique words in the vocabulary built from the 10 sentences.

Each position in the binary vector corresponds to a specific word in the vocabulary list. The value at that position will be '1' if that specific word appears in the sentence, and '0' otherwise.

Here's a simplified example to illustrate:

1. Let's say the vocabulary has only four unique words: `["apple", "orange", "banana", "grape"]`.
2. And you have a sentence: `I like apple and banana`.
3. The binary vector for this sentence would be `[1, 0, 1, 0]`.

- The first position corresponds to `apple`, which is in the sentence, so the first value is `1`.
- The second position corresponds to `orange`, which is not in the sentence, so the second value is `0`.
- The third position corresponds to `banana`, which is in the sentence, so the third value is `1`.
- The fourth position corresponds to `grape`, which is not in the sentence, so the fourth value is `0`.

This binary representation is a very basic form of text vectorization, and it allows you to translate textual information into a format that machine learning algorithms can understand. It's a starting point for many more complex methods in natural language processing.

Question 4: What information is lost when we represent sentences as binary vectors? Can you think of a real-world application where binary vectorization would be particularly useful?

Answer:: As far as I am concerned, the temperal information are lost in the seentence vectorization. It means that we cannot get the order of the words. we cannot know which word shows up first and which word shows second. We only know that which word shows up in this sentence. Besides, time of showing up is also lost since if a vocabulary shows up twice in the sentence, the vectorized data will only illustrate the word shows up in this sentence, but we don't knoe how many times the word shows up. Besides, it has a lot of computation cost and use a lot of memory to storage and compute the vector.

There are many senario that this algorithm can be used. For example, we are able to apply this algorithm in the retievel tasks so that when we are going to find the key word in the text, it will be easier.

4.5 Task 5 (7 points)

Word2Vec is a more advanced technique that represents each word in a continuous vector space. This method captures semantic relationships between words, unlike simple binary vectorization, which simply shows the presence or absence of a word in a sentence

So, in simple words, we match each word with its numerical value, which indicates its proximity to all other words words

```
[ ]: sentences = text.lower().translate(str.maketrans('', '', string.punctuation)).
     ↪split('.')
     tokenized_sentences = [sentence.split() for sentence in sentences]

     vector_size = 100  # Dimensionality of the word vectors. You can change this␣
     ↪and see what happens
     window_size = 5

     word2vec_model = Word2Vec(sentences = tokenized_sentences, vector_size =␣
     ↪vector_size, window = window_size, sg = 0, min_count = 1)

     word2vec_model.train(tokenized_sentences, total_examples =␣
     ↪len(tokenized_sentences), epochs=10)

     # Find the vector representation for specific words
     specific_words = ['ivanhoe', 'cedric']
     for word in specific_words:
         try:
             vector = word2vec_model.wv[word]
             print(f"The vector representation for the word '{word}' is {vector}")
         except KeyError:
             print(f"The word '{word}' does not exist in the vocabulary.")

     # Find the most similar words to a specific word
     try:
         similar_words = word2vec_model.wv.most_similar('ivanhoe', topn=5)
         print(f"The most similar words to 'ivanhoe' are: {similar_words}")
     except KeyError:
         print("The word 'ivanhoe' does not exist in the vocabulary.")
```

```
The vector representation for the word 'ivanhoe' is [-0.2643725    0.11630445
 0.09571383   0.4648072    0.10598736 -0.28989583
  0.34283152   0.69921976 -0.17512834 -0.4588505  -0.03199127 -0.5645581
  0.33445367   0.15859395 -0.11392275 -0.14727412   0.22653812 -0.2739206
 -0.29033983 -0.7211193    0.00345606   0.02429905   0.30712196 -0.1358171
  0.02908894 -0.03336852 -0.2569404   -0.06147575 -0.01772118 -0.01230178
  0.30185294 -0.3090063    0.08367046 -0.27269012 -0.06884061   0.48905656
  0.32561332 -0.18804917 -0.09022114 -0.48168546   0.16176187 -0.18921836
 -0.3307375    0.00366054   0.43951365 -0.13611576 -0.22531329 -0.17508073
  0.23828214   0.1434455   -0.07219192 -0.20450899 -0.09017924   0.02495505
```

```
  -0.06891233 -0.0961592    0.3507908  -0.10487615   0.01441604   0.21581583
  -0.22138269 -0.17085604   0.13846418 -0.10771231  -0.20674925   0.41106966
   0.16794243   0.20932359 -0.3141187    0.40275985  -0.0187368    0.2866025
   0.3805522  -0.0863899    0.48730206 -0.16541998   0.19281414  -0.05114263
  -0.33949852   0.09780239 -0.4262745   -0.13469714  -0.17207082   0.21389784
  -0.30757272 -0.4353743    0.05651349 -0.12496158   0.33363283  -0.01389757
   0.4295535    0.18449096 -0.1749594    0.06676935   0.78725684   0.1731143
  -0.14255586 -0.28182602 -0.09623139   0.05206218]
The vector representation for the word 'cedric' is [-0.05004271  0.02865341
 0.02141572  0.10486725  0.02887011 -0.05845363
   0.0666513    0.14613806 -0.04444141 -0.08616571 -0.01023106 -0.10663676
   0.05665387   0.02761171 -0.0126151  -0.03473501   0.0434182  -0.05272097
  -0.05313112 -0.1492859  -0.00656841   0.0143087    0.05504245 -0.02518469
   0.01226045 -0.01277786 -0.0591888  -0.0237504   -0.00372091   0.00358084
   0.05226975 -0.06734862   0.02591989 -0.05975037 -0.00967915   0.10264098
   0.06476363 -0.04679336 -0.0100009   -0.10132194   0.04147498 -0.04044114
  -0.06450249   0.00810895   0.09115107 -0.02440191 -0.05157842 -0.02643256
   0.04849188   0.02174878 -0.0101085   -0.03297796 -0.0229317    0.0055887
  -0.0073165   -0.02295013   0.07316424 -0.0120969    0.01101731   0.03730094
  -0.04919771 -0.02403123   0.0277964   -0.03319504 -0.041324     0.07840479
   0.03439643   0.04416823 -0.06945681   0.07840071   0.00447678   0.06216792
   0.08076686 -0.01546171   0.10714062 -0.03581383   0.04498849 -0.01155931
  -0.07753966   0.00952141 -0.08754049 -0.0204932   -0.03104032   0.03745691
  -0.0612942   -0.09054261   0.00638283 -0.0158815    0.0721553   -0.00203359
   0.09138633   0.04005494 -0.0443504    0.01663842   0.16780123   0.03797898
  -0.02675109 -0.05916311 -0.01677116   0.00209704]
The most similar words to 'ivanhoe' are: [('his', 0.9997226595878601), ('that',
0.999718427658081), ('and', 0.9997158646583557), ('to', 0.9997157454490662),
('an', 0.9997115731239319)]
```

You see that vector representation of the word is as big as binary vectorization of the whole sentence! However, with bigger dimensional comes bigger precision: in natural language processing, representing words as vectors in a high-dimensional space is a common technique to capture semantic and syntactic information about the words. When we say that the vector representation for a word is "big," we usually refer to the number of dimensions the vector has.

The more dimensions you have, the easier it is to distinguish between words. When you have a large vocabulary, being able to separate words distinctly in the vector space is crucial for tasks like classification, clustering, or similarity measurement.

Now it is your turn to find the most similar word to the word *knight*

```
[ ]: word = 'knight' # YOUR CODE
     try:
         similar_words = word2vec_model.wv.most_similar(word, topn=5)
         print(f"The most similar words to 'knight' are: {similar_words}")
     except KeyError:
         print("The word 'knight' does not exist in the vocabulary.")
```

```
The most similar words to 'knight' are: [('newly', 0.3899497389793396), ('pale',
```

0.3827079236507416), ('pavement"', 0.37549522519111633), ('jugglers',
0.3536728322505951), ('heaven', 0.3529618978500366)]

Question 5: What are the benefits and limitations of using a high-dimensional space for word vectors?

Answer: Benifits: There aseveral benifits in NLP field to use the high-dimensional spcae for word vector. On the one hand, encoding the word into high dimensional vector is able to enhance the reprensatation of the model. As a result, the model may have the higher performance in the tasks. Besides, there will be less over lapping between each words in the encoding.

Limitations: Encoding the word into high dimensional vectors may cause a lot of computational cost during the computation. The higher number of dimension also make the model easier to be over fitting.

4.6 Task 6 (7 points)

The task of finding synonyms and antonyms in text is crucial for several reasons, spanning various fields like natural language processing, linguistics, and even cognitive science.

The identification of synonyms and antonyms is not merely a lexical exercise but a task that holds significant implications for both machine and human understanding of language. It is a foundational task in NLP and continues to be an area of active research and application.

Your task is to find synonyms and antonyms of the word *happy*

```python
text = text.lower().translate(str.maketrans('', '', string.punctuation))
sentences = text.split('.')
tokenized_sentences = [sentence.split() for sentence in sentences]

model = Word2Vec(sentences=tokenized_sentences, vector_size=100, window=5,
 ↪min_count=1)

def find_antonyms_by_negation(model, target_word, topn=10):
    try:
        neg_vector = -model.wv[target_word]
        similar_to_neg = model.wv.similar_by_vector(neg_vector, topn=topn)
        return similar_to_neg
    except KeyError:
        return f"{target_word} is not in vocabulary"

target_word = "happy"
try:
    similar_words = model.wv.most_similar(target_word, topn=10)
    print(f"Synonyms to word '{target_word}' in the context of the text:
 ↪{similar_words}")
except KeyError:
    print(f"'{target_word}' is not in vocabulary")

similar_to_neg = find_antonyms_by_negation(model, target_word)
```

```
print(f"Antonyms to word '{target_word}' in the context of the text:␣
  ↪{similar_to_neg}")
```

```
Synonyms to word 'happy' in the context of the text: [('wealthy',
0.43914794921875), ('ventured', 0.418487548828125), ('"wamba',
0.3840603530406952), ('landscape', 0.3736926317214966), ('hostile',
0.3642038404941559), ('voice', 0.36224544048309326), ('invented',
0.36121198534965515), ('mouldered', 0.35701826214790344), ('scene',
0.35492852330207825), ('natural', 0.3531250059604645)]
Antonyms to word 'happy' in the context of the text: [('blew',
0.40592625737190247), ('chimney-his', 0.3750070035457611), ('iron',
0.3697652816772461), ('sparkling', 0.3452267348766327), ('astonish'd',
0.34012579917907715), ('down-he', 0.3383086621761322), ('undenied',
0.33183708786964417), ('endeaver', 0.32978299260139465), ('wars"',
0.325703889131546), ('prior's', 0.317865788936615)]
```

The concepts of synonyms and antonyms are not as straightforward as they may appear because language is deeply context-dependent. Words that are synonyms or antonyms in one context may not hold the same relationship in another setting.

Because of these complexities, it's crucial to consider context when identifying synonyms and antonyms. In some cases, they can be tagged as such only within the specific text being analyzed.

Question 6: How would you handle words that have multiple meanings in the task of identifying synonyms and antonyms?

Answer: From my opinion, I suppose that concern the context words of the target word is important. For instance, we can infer a meaning/feature of a word according to 5 words around it. Considering the background of the word is able to get more accurate meaning of the target word.

4.7   Task 7 (9 points)

Summarization aims to reduce the content to its most essential points, delivering the same message but in a more concise manner. This is particularly useful for quickly understanding large volumes of text or identifying the most important information within a document.

In this task, you'll focus on summarizing a randomly selected sentence from a given text.

```
[ ]: tokenizer = BartTokenizer.from_pretrained("facebook/bart-large-cnn")
     model = BartForConditionalGeneration.from_pretrained("facebook/bart-large-cnn")
     summarizer = pipeline("summarization", model = model, tokenizer=tokenizer)
```

```
[ ]: text = read_document(data_path)
     sentences = text.split('. ')
     sentences = [s.strip() for s in sentences if s]

     random_sentence = random.choice([s for s in sentences if len(s) >= 30])
     summary = summarizer(random_sentence, max_length = 50, min_length = 5,␣
       ↪do_sample = False)
```

```
print("Original Sentence:", random_sentence)
print("Summary:", summary[0]['summary_text'])
```

Original Sentence: He therefore gently insinuated the incapacity of the native
of any other country to engage in the genial conflict of the bowl with
the hardy and strong-headed Saxons; something he mentioned, but
slightly, about his own holy character, and ended by pressing his
proposal to depart to repose.

The grace-cup was accordingly served round, and the guests, after
making deep obeisance to their landlord and to the Lady Rowena, arose
and mingled in the hall, while the heads of the family, by separate
doors, retired with their attendants.

"Unbelieving dog," said the Templar to Isaac the Jew, as he passed him
in the throng, "dost thou bend thy course to the tournament?"

"I do so propose," replied Isaac, bowing in all humility, "if it please
your reverend valour."

"Ay," said the Knight, "to gnaw the bowels of our nobles with usury,
and to gull women and boys with gauds and toys-I warrant thee store of
shekels in thy Jewish scrip."

"Not a shekel, not a silver penny, not a halfling-so help me the God of
Abraham!" said the Jew, clasping his hands; "I go but to seek the
assistance of some brethren of my tribe to aid me to pay the fine which
the Exchequer of the Jews have imposed upon me-Father Jacob be my
speed! I am an impoverished wretch-the very gaberdine I wear is
borrowed from Reuben of Tadcaster." 15

The Templar smiled sourly as he replied, "Beshrew thee for a
false-hearted liar!" and passing onward, as if disdaining farther
conference, he communed with his Moslem slaves in a language unknown to
the bystanders
Summary: The Knight insinuated the incapacity of the native Saxons of any other
country to engage in the genial conflict of the bowl with the hardy and strong-
headed Saxons. He mentioned, but slightly, about his own

Question 7: How well did the machine-generated summary capture the essence of the original text? What important details were omitted in the machine summary? What improvements would you suggest for the current summarization model?

Answer: The machine can summarize that the peoaple being described in this sentence is a clown and what is the clown doing in the sentence. However, the machine failed to point out that the expression of the countenance is also a cue to let us know he is a clown. I suppose that the model catch only one reason to infer he as aclown. We may concern that using a mechanism to capture the details in the sentences.

4.8 Bonus task (bonus 10 points)

The goal is to build a simple sentiment analyzer that categorizes the sentences from your original text as either 'positive' or 'negative'.

Description:

1. **Feature Extraction**: Utilize one of the vectorization techniques you've previously learned to turn your sentences into numerical data. This could be binary representation or Word2Vec.

2. **Model Training**: Use a straightforward machine learning model like Naive Bayes to train on this small dataset.

3. **Prediction**: Use the model to predict the sentiment of remaining sentences in the text. Display the sentences along with their predicted sentiments.

```python
sentences = sent_tokenize(text)

# Randomly select 1000 sentences for training
train_sentences = choices(sentences, k=1000) # YOUR CODE HERE

labels = [random.choice([0, 1]) for _ in range(len(train_sentences))]

# Feature extraction
vectorizer = CountVectorizer() # YOUR CODE HERE
X_train = vectorizer.fit_transform(train_sentences)# YOUR CODE HERE
```

```
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1000
```

```python
sentences = sent_tokenize(text)

# Randomly select 1000 sentences for training
train_sentences = random.choices(sentences, k=1000) # YOUR CODE HERE

labels = [random.choice([0, 1]) for _ in range(len(train_sentences))]

# Feature extraction
vectorizer = CountVectorizer() # YOUR CODE HERE
X_train = vectorizer.fit_transform(train_sentences)# YOUR CODE HERE

# Train a simple classifier
clf = MultinomialNB(force_alpha=True).fit(X_train, labels)# YOUR CODE HERE

remaining = list(set(sentences).difference(set(train_sentences)))

# Randomly select a sentence for testing
```

```
random_sentence = random.choice(remaining) # YOUR CODE HERE

# Make predictions
X_test = vectorizer.transform([random_sentence]) # YOUR CODE HERE
y_pred = clf.predict(X_test) # YOUR CODE HERE

# Map label to sentiment
sentiment = 'positive' if y_pred[0] == 1 else 'negative'

print(f"Sentence: {random_sentence}") # YOUR CODE HERE
print(f"Predicted Sentiment: {sentiment}") # YOUR CODE HERE
```

Sentence: "By Saint Thomas of Kent," said he, "an I buckle to my gear, I will teach thee, sir lazy lover, to mell with thine own matters, maugre thine iron case there!"

"Nay, be not wroth with me," said the Knight; "thou knowest I am thy sworn friend and comrade."

"I know no such thing," answered the Friar; "and defy thee for a meddling coxcomb!"

"Nay, but," said the Knight, who seemed to take a pleasure in provoking his quondam host, "hast thou forgotten how, that for my sake (for I say nothing of the temptation of the flagon and the pasty) thou didst break thy vow of fast and vigil?"

"Truly, friend," said the Friar, clenching his huge fist, "I will bestow a buffet on thee."

"I accept of no such presents," said the Knight; "I am content to take thy cuff 421 as a loan, but I will repay thee with usury as deep as ever thy prisoner there exacted in his traffic."

"I will prove that presently," said the Friar.
Predicted Sentiment: positive

Question 8: Can you explain what text vectorization is and why it's necessary for NLP tasks? Why is it important to split the data into training and test sets?

Answer: It is very important tp using text vectorization in the NLP descipline since the computer cannot directly understand the raw text. The text vectorization transform the raw text into the vector (which is consist of numbers) so that can be processed with multiple algorithms. It is also very essential to split data into training set and test set for the reason that there will be the data leakage when we use training set to test the model. When we use the brand new data with the model, the performance of the model will drop significantly. Using training set to measure a model will make it be lack of generalization.