Introduction

Welcome to the second session of first module. In the last session, you learnt regular expressions and their use cases. That was a very essential skill to learn before applying your hands on any kind of text processing.

In this session you will learn basic lexical processing. You will get to know the various preprocessing steps you need to apply before you can do any kind of text analytics such as apply machine learning on text, building language models, building chatbots, building sentiment analysis systems and so on. These steps are used in almost all applications that work with textual data. We will also build a spam-ham detector system side-by-side on a very unclean corpus of text. Corpus is just a name to refer to textual data in NLP jargon.

Now, you have already built a spam detector while learning about the naive-bayes classifier. Here, you will learn all the preprocessing steps that one needs to do before using a machine learning algorithm on the spam messages dataset. Note that, the preprocessing steps that we teach you here are not limited to building a spam detector.

Specifically, you will learn:

How to preprocess text using techniques such as

```
Tokenisation

Stop words removal

Stemming

Lemmatization
```

How to build a spam detector using one of the following models:

```
Bag-of-words model

TF-IDF model
```

Word Frequencies and Stop Words

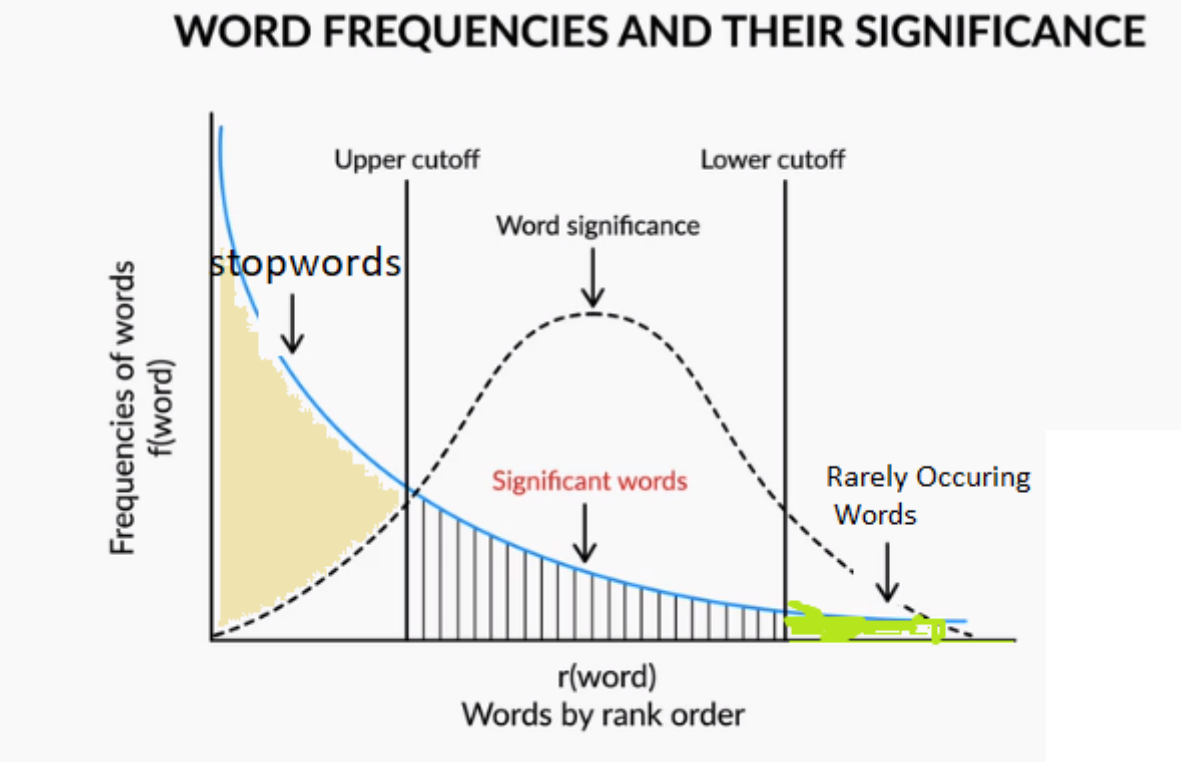
While working with any kind of data, the first step that you usually do is to explore and understand it better. In order to explore text data, you need to do some basic preprocessing steps. In the next few segments, you will learn some basic preprocessing and exploratory steps applicable to almost all types of textual data.

Now, a text is made of characters, words, sentences and paragraphs. The most basic statistical analysis you can do is to look at the word frequency distribution, i.e. visualising the word frequencies of a given text corpus.

It turns out that there is a common pattern you see when you plot word frequencies in a fairly large corpus of text, such as a corpus of news articles, user reviews, Wikipedia articles, etc. In the following lecture, professor Srinath will demonstrate some interesting insights from word frequency distributions. You will also learn what stopwords are and why they are lesser relevant than other words.

Zip's law :

Regardless of what document we are considering, there is specific pattern in which words are distributed among the document.



To summarise, the Zipf's law (discovered by the linguist-statistician George Zipf) states that the frequency of a word is inversely proportional to the rank of the word, where rank 1 is given to the most frequent word, 2 to the second most frequent and so on. This is also called the power law distribution.

The Zipf's law helps us form the basic intuition for stopwords - these are the words having the highest frequencies (or lowest ranks) in the text, and are typically of limited 'importance'.

Broadly, there are three kinds of words present in any text corpus:

Highly frequent words, called stop words, such as ‘is’, ‘an’, ‘the’, etc.

Significant words, which are typically more important to understand the text

Rarely occurring words, which are again less important than significant words

Generally speaking, stopwords are removed from the text for two reasons:

They provide no useful information, especially in applications such as spam detector or search engine. Therefore, you’re going to remove stopwords from the spam dataset.

Since the frequency of words is very high, removing stopwords results in a much smaller data as far as the size of data is concerned. Reduced size results in faster computation on text data. There’s also the advantage of less number of features to deal with if stopwords are removed.

However, there are exceptions when these words should not be removed. In the next module, you’ll learn concepts such as POS (parts of speech) tagging and parsing where stopwords are preserved because they provide meaningful (grammatical) information in those applications. Generally, stopwords are removed unless they prove to be very helpful in your application or analysis.

On the other hand, you’re not going to remove the rarely occurring words because they might provide useful information in spam detection. Also, removing them provides no added efficiency in computation since their frequency is so low.

In [1]:

```
import requests
from nltk import FreqDist
from nltk.corpus import stopwords
import seaborn as sns
%matplotlib inline
```

Download text of 'Alice in Wonderland' ebook from https://www.gutenberg.org/ (https://www.gutenberg.org/)

In [2]:

```
url = "https://www.gutenberg.org/files/11/11-0.txt"
alice = requests.get(url)
print(alice.text)
```

```
Project Gutenberg’s Alice’s Adventures in Wonderland, by Lewis Carroll

This eBook is for the use of anyone anywhere at no cost and with
almost no restrictions whatsoever.  You may copy it, give it away or
re-use it under the terms of the Project Gutenberg License included
with this eBook or online at www.gutenberg.org


Title: Alice’s Adventures in Wonderland

Author: Lewis Carroll

Posting Date: June 25, 2008 [EBook #11]
Release Date: March, 1994
Last Updated: October 6, 2016

Language: English

Character set encoding: UTF-8
```

Define a function to plot word frequencies

In [4]:

```
def plot_word_frequency(words, top_n=10):
    word_freq = FreqDist(words)
    labels = [element[0] for element in word_freq.most_common(top_n)]
    counts = [element[1] for element in word_freq.most_common(top_n)]
    plot = sns.barplot(labels, counts)
    return plot
```

Plot words frequencies present in the gutenberg corpus

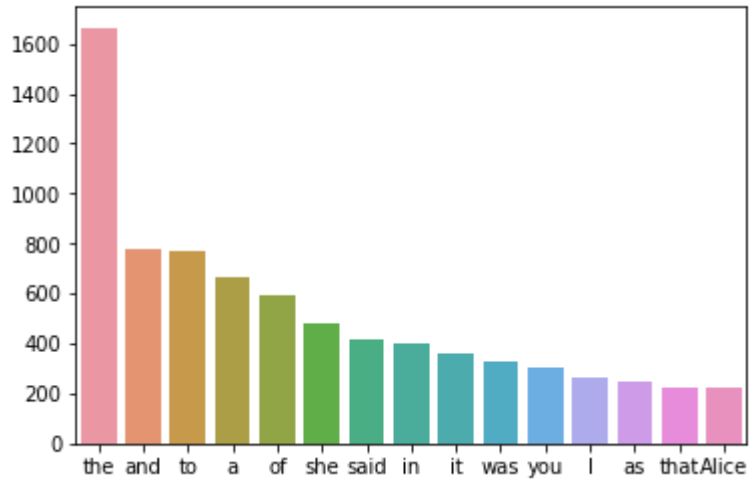
In [20]:

```
alice_words = alice.text.split()
print(alice_words[1])
plot_word_frequency(alice_words, 15)
```

```
Gutenberg’s
```

Out[20]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x20657196320>
```



Stopwords

Import stopwords from nltk

In [6]:

```
from nltk.corpus import stopwords
```

Look at the list of stopwords

In [7]:

```
print(stopwords.words('english'))
```

```
['i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', 'you', "you're
e", "you've", "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves',
'he', 'him', 'his', 'himself', 'she', "she's", 'her', 'hers', 'herself', 'i
t', "it's", 'its', 'itself', 'they', 'them', 'their', 'theirs', 'themselve
s', 'what', 'which', 'who', 'whom', 'this', 'that', "that'll", 'these', 'tho
se', 'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has',
'had', 'having', 'do', 'does', 'did', 'doing', 'a', 'an', 'the', 'and', 'bu
t', 'if', 'or', 'because', 'as', 'until', 'while', 'of', 'at', 'by', 'for',
'with', 'about', 'against', 'between', 'into', 'through', 'during', 'befor
e', 'after', 'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'o
n', 'off', 'over', 'under', 'again', 'further', 'then', 'once', 'here', 'the
re', 'when', 'where', 'why', 'how', 'all', 'any', 'both', 'each', 'few', 'mo
re', 'most', 'other', 'some', 'such', 'no', 'nor', 'not', 'only', 'own', 'sa
me', 'so', 'than', 'too', 'very', 's', 't', 'can', 'will', 'just', 'don', "d
on't", 'should', "should've", 'now', 'd', 'll', 'm', 'o', 're', 've', 'y',
'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'doesn', "d
oesn't", 'hadn', "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "is
n't", 'ma', 'mightn', "mightn't", 'mustn', "mustn't", 'needn', "needn't", 's
han', "shan't", 'shouldn', "shouldn't", 'wasn', "wasn't", 'weren', "were
n't", 'won', "won't", 'wouldn', "wouldn't"]
```

Let's remove stopwords from the following piece of text.

In [8]:

```
sample_text = "the great aim of education is not knowledge but action"
```

Break text into words

In [9]:

```
sample_words = sample_text.split()
print(sample_words)
```

```
['the', 'great', 'aim', 'of', 'education', 'is', 'not', 'knowledge', 'but',
'action']
```

Remove stopwords

In [11]:

```
sample_words = [word for word in sample_words if word not in stopwords.words('english')]
print(sample_words)
```

```
['great', 'aim', 'education', 'knowledge', 'action']
```

Join words back to sentence

In [12]:

```
sample_text = " ".join(sample_words)
print(sample_text)
```

```
great aim education knowledge action
```

Removing stopwords in the genesis corpus

In [13]:

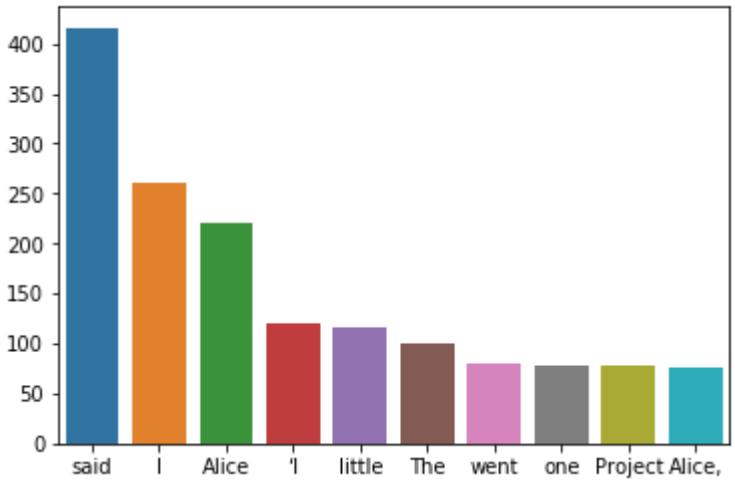
```
no_stops = [word for word in alice_words if word not in stopwords.words("english")]
```

In [14]:

```
plot_word_frequency(no_stops, 10)
```

Out[14]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x20656cf2d68>
```



Some other things that can be done

- Need to change tokens to lower case
- Need to get rid of punctuations

All the preprocessing steps will be covered while creating the classifier

Description

You learnt how to extract and plot word frequencies from a list of words. In this exercise, you need to extract the third most frequent word of a book (the book is provided) and print it's frequency.

In [21]:

```
import requests
from nltk import FreqDist

# load the ebook
url = "https://www.gutenberg.org/files/16/16-0.txt"
peter_pan = requests.get(url).text

# break the book into different words using the split() method
peter_pan_words = peter_pan.split()# write your code here

# build frequency distribution using NLTK's FreqDist() function
word_frequency = FreqDist(peter_pan_words)# write your code here

# extract the frequency of third most frequent word
freq = word_frequency.most_common(3)[2][1]

# print the third most frequent word - don't change the following code, it is used to evalu
print(freq)
```

```
1214
```

In [22]:

```
word_frequency
```

Out[22]:

```
FreqDist({'the': 2331, 'and': 1396, 'to': 1214, 'a': 962, 'of': 929, 'was':
898, 'he': 866, 'in': 683, 'that': 564, 'had': 498, ...})
```

Description

In this exercise, you'll remove stop words in a given corpus of text of a book. Then, you'll print the frequency of the most frequent word.

In [27]:

```
import requests
from nltk import FreqDist
from nltk.corpus import stopwords

# load the ebook
url = "https://www.gutenberg.org/files/16/16-0.txt"
peter_pan = requests.get(url).text

# break the book into different words using the split() method
peter_pan_words = peter_pan.split()

# build frequency distribution using NLTK's FreqDist() function
word_frequency = FreqDist(peter_pan_words)

# extract nltk stop word list
stopwords = stopwords.words('english')

# remove 'stopwords' from 'peter_pan_words'
#no_stops = [word for word in alice_words if word not in stopwords.words("english")]
no_stops = [word for word in peter_pan_words if word not in stopwords] # write code here

# create word frequency of no_stops
word_frequency = FreqDist(no_stops)# write code here

# extract the most frequent word and its frequency
frequency = word_frequency.most_common(1)[0][1]

# print the third most frequent word - don't change the following code, it is used to evalu
print(frequency)
```

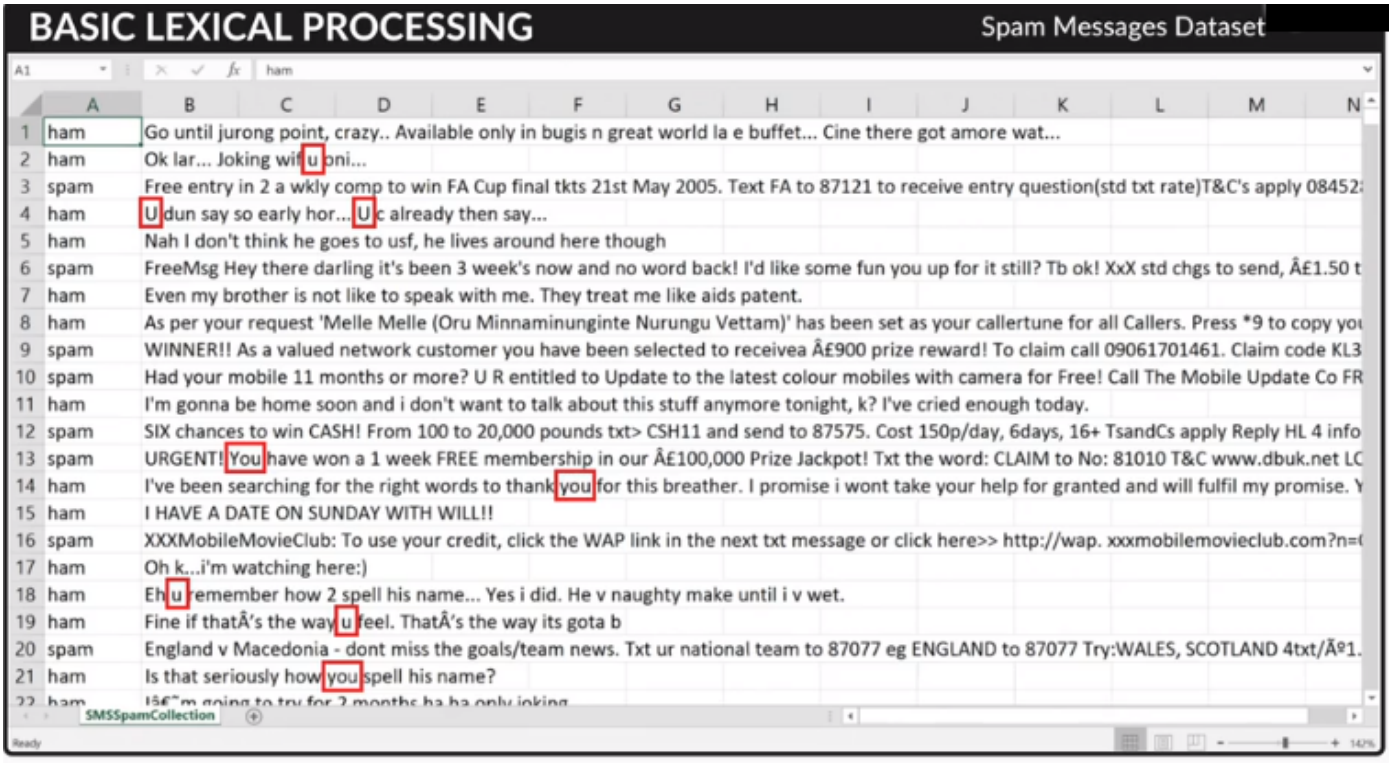
```
253
```

Tokenisation

You already know that you're going to build a spam detector by the end of this module. In the spam detector application, you're going to use word tokenisation, i.e. break the text into different words, so that each word can be used as a feature to detect whether the given message is a spam or not.

Now, let's take a look at the spam messages dataset to get a better understanding of how to approach the problem of building a spam detector.

The data will contain noise as below



As you saw, there is a lot of noise in the data. Noise is in the form of non-uniform cases, punctuations, spelling errors. These are exactly the things that make it hard for anyone to work on text data.

There is another thing to think about - how to extract features from the messages so that they could be used to build a classifier. When you create any machine learning model such as a spam detector, you will need to feed in features related to each message that the machine learning algorithm can take in and build the model. But here, in the spam dataset, you only have two columns - one column contains the message and the other contains the label related to the message. And as you know, machine learning works on numeric data, not text. Earlier when you worked with text columns, you either treated them as categorical variables and converted each categorical variable to numeric variable by either assigning numeric values to each category, or you created dummy variables. Here, you can do neither of these, since the message column is unique, it's not a categorical variable. If you treat it as a category, your model will fail miserably. You can try it as an exercise.

To deal with this problem, you will extract features from the messages. From each message you'll extract each word by breaking each message into separate words or 'tokens'.

This technique is called tokenisation - a technique that's used to split the text into smaller elements. These elements can be characters, words, sentences, or even paragraphs depending on the application you're working on.

In the spam delector case, you will break each message into different words, so it's called word tokenisation. Similarly, you have other types of tokenisation techniques such as character tokenisation, sentence tokenisation, etc. Different types of tokenisation are needed in different scenarios.

Now, let's take a look at what exactly tokenisation is and how to do it in NLTK. Prof Me walks you through the process using the following Jupyter notebook.

Tokenisation

The notebook contains three types of tokenisation techniques:

Word tokenisation

Sentence tokenisation

Tweet tokenisation

Custom tokenisation using regular expressions

1. Word tokenisation

In [28]:

```
document = "At nine o'clock I visited him myself. It looks like religious mania, and he'll
print(document)
```

```
At nine o'clock I visited him myself. It looks like religious mania, and h
e'll soon think that he himself is God.
```

Tokenising on spaces using python

In [29]:

```
from nltk.tokenize import word_tokenize
words = word_tokenize(document)
```

In [30]:

```
print(words)
```

```
['At', 'nine', "o'clock", 'I', 'visited', 'him', 'myself', '.', 'It', 'look
s', 'like', 'religious', 'mania', ',', 'and', 'he', "'ll", 'soon', 'think',
'that', 'he', 'himself', 'is', 'God', '.']
```

NLTK's word tokeniser not only breaks on whitespaces but also breaks contraction words such as he'll into "he" and "'ll". On the other hand it doesn't break "o'clock" and treats it as a separate token.

2. Sentence tokeniser

Tokenising based on sentence requires you to split on the period ('.'). Let's use nltk sentence tokeniser.

In [31]:

```
from nltk.tokenize import sent_tokenize
sentences = sent_tokenize(document)
```

In [32]:

```
print(sentences)
```

```
["At nine o'clock I visited him myself.", "It looks like religious mania, an
d he'll soon think that he himself is God."]
```

3. Tweet tokeniser

A problem with word tokeniser is that it fails to tokeniser emojis and other complex special characters such as word with hashtags. Emojis are common these days and people use them all the time.

In [33]:

```
message = "i recently watched this show called mindhunters:). i totally loved it 😍. it wa
```

In [34]:

```
print(word_tokenize(message))
```

```
['i', 'recently', 'watched', 'this', 'show', 'called', 'mindhunters', ':',
')', '.', 'i', 'totally', 'loved', 'it', '😍', '.', 'it', 'was', 'gr8', '<',
'3', '.', '#', 'bingewatching', '#', 'nothingtodo', '😎']
```

The word tokeniser breaks the emoji '<3' into '<' and '3' which is something that we don't want. Emojis have their own significance in areas like sentiment analysis where a happy face and sad face can salone prove to be a really good predictor of the sentiment. Similarly, the hashtags are broken into two tokens. A hashtag is used for searching specific topics or photos in social media apps such as Instagram and facebook. So there, you want to use the hashtag as is.

Let's use the tweet tokeniser of nltk to tokenise this message.

In [36]:

```
from nltk.tokenize import TweetTokenizer
tknzr = TweetTokenizer()
```

In [37]:

```
tknzr.tokenize(message)
```

Out[37]:

```
['i',
 'recently',
 'watched',
 'this',
 'show',
 'called',
 'mindhunters',
 ':)',
 '.',
 'i',
 'totally',
 'loved',
 'it',
 '😍',
 '.',
 'it',
 'was',
 'gr8',
 '<3',
 '.',
 '#bingewatching',
 '#nothingtodo',
 '🤓']
```

As you can see, it handles all the emojis and the hashtags pretty well.

Now, there is a tokeniser that takes a regular expression and tokenises and returns result based on the pattern of regular expression.

Let's look at how you can use regular expression tokeniser.

In [38]:

```
from nltk.tokenize import regexp_tokenize
message = "i recently watched this show called mindhunters:). i totally loved it 😍. it wa
pattern = "#[\w]+"
```

In [39]:

```
regexp_tokenize(message, pattern)
```

Out[39]:

```
['#bingewatching', '#nothingtodo']
```

There are multiple ways of doing a particular thing in Python. To tokenise words, you can use the split() method that just splits text on white spaces, by default. This method doesn't always give good results. You are better off using NLTK's tokeniser which handles various complexities of text. One of them is that it handles contractions such as "can't", "hasn't", "wouldn't", and other contraction words and splits these up although there is no space between them. On the other hand, it is smart enough to not split words such as "o'clock" which is not a contraction word.

In NLTK, you also have different types of tokenisers present that you can use in different applications. The most popular tokenisers are:

1.Word tokeniser splits text into different words.

2.Sentence tokeniser splits text in different sentence.

3.Tweet tokeniser handles emojis and hashtags that you see in social media texts

4.Regex tokeniser lets you build your own custom tokeniser using regex patterns of your choice.

Description

Write a piece of code that breaks a given sentence into words and store them in a list. Then print the list as well as the length of the list. Use the NLTK tokeniser to tokenise words.

Sample input: "I love pasta"

In [41]:

```
from nltk.tokenize import word_tokenize
import ast, sys
sentence = "I love pasta"

# tokenise sentence into words
words = word_tokenize(sentence)# write your code here

# print length - don't change the following piece of code
print(len(words))
```

```
3
```

Description

Write a piece of code that breaks a given sentence into words and stores them in a list. Then remove the stop words from this list and then print the list as well as the length of the list. Again, use the NLTK tokeniser to do this.

Sample input: "Education is the most powerful weapon that you can use to change the world"

In [42]:

```
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
import ast, sys
sentence = "Education is the most powerful weapon that you can use to change the world"

# change sentence to lowercase
sentence = sentence.lower() # write code here

# tokenise sentence into words
words =  word_tokenize(sentence)# write code here

# extract nltk stop word list
stopwords = stopwords.words('english')# write code here

# remove stop words
no_stops = [word for word in words if word not in stopwords]# write code here

# print length - don't change the following piece of code
print(len(no_stops))
```

6

Description

Write a Python code using the NLTK library that breaks a given piece of text containing multiple sentences into different sentences. Finally print the total number of sentences in the text.

Sample input: Develop a passion for your learning. If you do, you'll never cease to grow.

In [44]:

```
from nltk.tokenize import sent_tokenize
from nltk.corpus import stopwords
import ast, sys
text = "Develop a passion for your learning. If you do, you'll never cease to grow."

# change sentence to lowercase
text = text.lower()#write code here

# tokenise sentence into words
sentences = sent_tokenize(text)# write code here

# print length - don't change the following piece of code
print(len(sentences))
```

2

Description

Use NLTK's regex tokeniser to extract all the mentions from a given tweet and then print the total number of mentions. A mention comprises of a '@' symbol followed by a username containing either alphabets, numbers or underscores.

Sample tweet:

So excited to be a part of machine learning and artificial intelligence program made by @baba and @iit

Expected output:

2 (because there are two mentions - '@baba' and '@iit')

In [47]:

```
from nltk.tokenize import regexp_tokenize
from nltk.corpus import stopwords
import ast, sys
text = "So excited to be a part of machine learning and artificial intelligence program mad

# change text to lowercase
text = text.lower()# write code here

# pattern to extract mentions
pattern = '@[\w]+'# write regex pattern here

# extract mentions by using regex tokeniser
mentions = regexp_tokenize(text,pattern)# write code here

# print length - don't change the following piece of code
print(len(mentions))
```

```
2
```

Bag-of-Words Representation

You have now learnt two preprocessing steps - tokenisation and removing stopwords. But you still can't use the list of words that you get after these processing steps to train a machine learning model.

In this section, you'll learn how to represent text in a format that you can feed into machine learning algorithms. The most common and most popular approach is to create a bag-of-words representation of the text data that you have. The central idea is that any given piece of text, i.e., tweets, articles, messages, emails etc., can be "represented" by a list of all the words that occur in it (after removing the stopwords), where the sequence of occurrence does not matter. You can visualise it as the "bag" of all "words" that occur in it. For example, consider the messages:

"Gangs of Wasseypur is a great movie"

The bag of words representation for this message would be:

Bag-of-words representation

This way, you can create “bags” for representing each of the messages in your training and test data set. But how do you go from these bags to building a spam classifier?

Let’s say the bags, for most of the spam messages, contain words such as prize, lottery etc., and most of the ham bags don’t. Now, whenever you run into a new message, just look at its “bag-of-words” representation. Does the bag for this message resemble that of messages you already know as spam, or does it not resemble them? Based on the answer to the previous question, you can then classify the message.

Now, the next question is, how do you get a machine to do all of that? Well, turns out that for doing that, you need to represent all the bags in a matrix format, after which you can use ML algorithms such as naive Bayes, logistic regression, SVM etc., to do the final classification.

But how is this matrix representation created? Let’s understand it from professor ME.

BAG-OF-WORDS MODEL

Document 1 : “Gangs of Wasseypur is a great movie.”
Document 2 : “The success of a movie depends on the performance of the actors.”
Document 3 : “There are no new movies releasing this week.”

	actors	great	depends	gangs	movie	movies	new	performance	releasing	success	wasseypur	week
1	0	1	0	1	1	0	0	0	0	0	1	0
2	1	0	1	0	1	0	0	1	0	1	0	0
3	0	0	0	0	0	1	1	0	1	0	0	1

So, that’s how text is represented in the form of matrix. It can then be used to train machine learning models. Each document sits on a separate row and each word of the vocabulary has a its own column. These vocabulary words are also called as features of the text.

The bag-of-words representation is also called bag-of-words model but this is not to be confused with a machine learning model. A bag-of-words model is just the matrix that you get from text data.

Another thing to note is that the values inside any cell can be filled in two ways - 1) you can either fill the cell with the frequency of a word (i.e. a cell can have a value of 0 or more), or 2) fill the cell with either 0, in case the word is not present or 1, in case the word is present (binary format).

Both approaches work fine and don't usually result in a big difference. The frequency approach is slightly more popular and the NLTK library in Python also fills the bag-of-words model with word frequencies rather than binary 0 or 1 values.

Now, it's your turn to create a bag of words model. Consider these documents and create a bag-of-words model with the frequency approach on these documents. Please note that there is no need to remove the stop words in this case (just for this exercise). After you're done creating the model, answer the questions that follow.

Document 1: "there was a place on my ankle that was itching"

Document 2: "but I did not scratch it"

Document 3: "and then my ear began to itch"

Document 4: "and next my back"

Now, let's see how bag-of-words model is built in Python. Download the Jupyter notebook of the code here, to follow along:

Bag of words model

In [1]:

```
# load all necessary libraries
import pandas as pd
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
from sklearn.feature_extraction.text import CountVectorizer

pd.set_option('max_colwidth', 100)
```

Let's build a basic bag of words model on three sample documents

In [10]:

```
documents = ["Gangs of Wasseypur is a great movie.", "The success of a movie depends on the
print(documents)
```

```
['Gangs of Wasseypur is a great movie.', 'The success of a movie depends on
the performance of the actors.', 'There are no new movies releasing this wee
k.']
```

In [11]:

```
def preprocess(document):
    'changes document to lower case and removes stopwords'

    # change sentence to lower case
    document = document.lower()

    # tokenize into words
    words = word_tokenize(document)

    # remove stop words
    words = [word for word in words if word not in stopwords.words("english")]

    # join words to make sentence
    document = " ".join(words)

    return document

documents = [preprocess(document) for document in documents]
print(documents)
```

```
['gangs wasseypur great movie .', 'success movie depends performance actors
.', 'new movies releasing week .']
```

Creating bag of words model using count vectorizer function

In [12]:

```
vectorizer = CountVectorizer()
bow_model = vectorizer.fit_transform(documents)
print(bow_model)  # returns the rown and column number of cells which have 1 as value
```

```
  (0, 4)        1
  (0, 3)        1
  (0, 10)       1
  (0, 2)        1
  (1, 0)        1
  (1, 7)        1
  (1, 1)        1
  (1, 9)        1
  (1, 4)        1
  (2, 11)       1
  (2, 8)        1
  (2, 5)        1
  (2, 6)        1
```

In [13]:

```
# print the full sparse matrix
print(bow_model.toarray())
```

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

In [51]:

```
print(bow_model.shape)
print(vectorizer.get_feature_names())
import numpy as np

print(bow_model.sum())
```

```
(100, 640)
['000', '07732584351', '0800', '08000930705', '08002986030', '08452810075ove
r18', '09061209465', '09061701461', '09066364589', '10', '100', '1000', '10a
m', '11', '12', '1500', '150p', '150pm', '16', '169', '18', '20', '2005', '2
1st', '2nd', '3aj', '4403ldnw1a7rw18', '450ppw', '4txt', '50', '5000', '524
9', '530', '5we', '6031', '6days', '81010', '85069', '87077', '87121', '8757
5', '8am', '900', '92h', '9pm', 'abiola', 'abt', 'ac', 'accomodations', 'ac
o', 'actin', 'advise', 'aft', 'afternoon', 'ah', 'ahead', 'ahhh', 'aids', 'a
lmost', 'already', 'alright', 'always', 'amore', 'amp', 'animation', 'anothe
r', 'anymore', 'anything', 'apologetic', 'apply', 'appointment', 'arabian',
'ard', 'around', 'ask', 'available', 'awarded', 'babe', 'back', 'badly', 'ba
rbie', 'becoz', 'bed', 'beforehand', 'best', 'bit', 'blessing', 'bonus', 'bo
x', 'breather', 'britney', 'brother', 'buffet', 'bugis', 'burger', 'burns',
'bus', 'buy', 'bx420', 'ca', 'call', 'callers', 'callertune', 'calls', 'camc
order', 'came', 'camera', 'car', 'cash', 'casualty', 'catch', 'caught', 'cau
se', 'cave', 'chances', 'charged', 'check', 'checking', 'cheers', 'chgs', 'c
hild', 'cine', 'cinema', 'claim', 'class', 'clear', 'click', 'close', 'co',
'code', 'coffee', 'coins', 'collected', 'colour', 'com', 'come', 'comes', 'c
omin', 'comp', 'complimentary', 'confirm', 'congrats', 'convincing', 'cool',
'copy', 'correct', 'cost', 'could', 'crashing', 'crave', 'crazy', 'credit',
'cried', 'csh11', 'cup', 'cuppa', 'customer', 'cut', 'da', 'darling', 'dat
e', 'day', 'dbuk', 'decide', 'decided', 'dedicate', 'dedicated', 'delivery',
'detroit', 'devils', 'dignity', 'dinner', 'dis', 'divorce', 'done', 'dont',
'double', 'download', 'dresser', 'dun', 'early', 'earn', 'eat', 'eating', 'e
g', 'egg', 'eh', 'eighth', 'ela', 'embarassed', 'embarassing', 'end', 'endow
ed', 'england', 'enough', 'entitled', 'entry', 'entry41', 'etc', 'eurodisin
c', 'even', 'fa', 'factory', 'fainting', 'fair', 'fallen', 'fear', 'feel',
'fffffffff', 'final', 'find', 'fine', 'finish', 'finished', 'first', 'fml',
'following', 'forced', 'forever', 'forget', 'forgot', 'four', 'free', 'freem
sg', 'friends', 'frnds', 'frying', 'fulfil', 'fun', 'fyi', 'gauti', 'gentlem
an', 'get', 'gets', 'getting', 'girls', 'give', 'go', 'goals', 'goes', 'goin
g', 'gon', 'good', 'got', 'gota', 'gram', 'granted', 'great', 'gt', 'guarant
eed', 'ha', 'hair', 'hairdressers', 'half', 'happy', 'havent', 'hear', 'he
e', 'hello', 'help', 'hep', 'hey', 'hi', 'hl', 'hockey', 'hols', 'home', 'ho
pe', 'hopefully', 'hor', 'hospital', 'hospitals', 'hours', 'housework', 'htt
p', 'hungry', 'hurts', 'ice', 'il', 'im', 'immunisation', 'inches', 'include
s', 'incorrect', 'info', 'invite', 'ip4', 'iq', 'jacket', 'jackpot', 'jerse
y', 'job', 'joke', 'joking', 'jurong', 'kano', 'ken', 'kept', 'killing', 'kl
341', 'know', 'knows', 'la', 'lar', 'late', 'later', 'latest', 'lccltd', 'le
arn', 'left', 'lesson', 'let', 'letter', 'lido', 'like', 'liked', 'link', 'l
ive', 'lives', 'll', 'loads', 'loans', 'lol', 'look', 'looking', 'lor', 'lov
e', 'loves', 'ls1', 'lt', 'lucky', 'lunch', 'macedonia', 'machan', 'make',
'mallika', 'man', 'mark', 'matrix3', 'may', 'maybe', 'means', 'meet', 'meeti
ng', 'melle', 'membership', 'message', 'messages', 'minnaminunginte', 'mis
s', 'missed', 'mix', 'mk17', 'mmmmmm', 'mob', 'mobile', 'mobiles', 'mom', 'm
oney', 'month', 'months', 'morefrmmob', 'morning', 'move', 'movie', 'msg',
'much', 'multis', 'na', 'nah', 'name', 'national', 'naughty', 'need', 'net',
'network', 'never', 'new', 'news', 'next', 'nice', 'nigeria', 'night', 'nitr
os', 'nokia', 'nurungu', 'odi', 'offered', 'oh', 'ok', 'one', 'oni', 'oops',
'operate', 'oru', 'pa', 'packing', 'pain', 'part', 'pass', 'password', 'pate
```

```
nt', 'pay', 'peoples', 'per', 'performed', 'pick', 'pizza', 'place', 'plan
e', 'planning', 'play', 'please', 'pleased', 'pleasure', 'pls', 'po', 'pobo
x', 'poboxox36504w45wq', 'point', 'pounds', 'pours', 'press', 'prize', 'pro
b', 'promise', 'qjkgighjjgcbl', 'question', 'quick', 'rain', 'rate', 'rcv',
're', 'reached', 'real', 'realized', 'really', 'receive', 'receivea', 'recen
t', 'red', 'remember', 'reply', 'replying', 'representative', 'request', 're
quests', 'respect', 'review', 'reward', 'ride', 'right', 'ringtone', 'rodge
r', 'room', 'roommate', 'roommates', 'rply', 'run', 'runs', 'said', 'sarcast
ic', 'saturday', 'save', 'saw', 'say', 'scotland', 'searching', 'second', 's
ee', 'seeing', 'seekers', 'seemed', 'sehwag', 'selected', 'send', 'series',
'seriously', 'service', 'set', 'sheets', 'sherawat', 'short', 'show', 'showe
r', 'shracomorsglsuplt', 'shy', 'sick', 'simply', 'since', 'situation', 'si
x', 'slice', 'smarter', 'smile', 'smiling', 'sms', 'smth', 'someone', 'somet
hing', 'song', 'soon', 'sooner', 'sorry', 'speak', 'special', 'spell', 'spen
t', 'spoilt', 'sptv', 'stand', 'started', 'starwars3', 'std', 'steed', 'stil
l', 'stock', 'stop', 'str', 'stubborn', 'stuff', 'stuff42moro', 'subscriptio
n', 'sucker', 'suckers', 'sucks', 'sum1', 'sunday', 'suprman', 'sure', 'swee
t', 'ta', 'take', 'talk', 'tb', 'tea', 'team', 'tell', 'telling', 'telugu',
'text', 'texting', 'thank', 'thanks', 'that', 'thats', 'think', 'thinked',
'tho', 'though', 'thought', 'tickets', 'till', 'time', 'times', 'timings',
'tkts', 'today', 'tomo', 'tomorrow', 'tonight', 'took', 'trav', 'treat', 'tr
ied', 'trip', 'trouble', 'try', 'trying', 'tsandcs', 'turn', 'txt', 'tyler',
'uk', 'update', 'ur', 'urgent', 'urgnt', 'url', 'us', 'use', 'used', 'usf',
'usher', 'usually', 'vaguely', 'valid', 'valuable', 'valued', 've', 'verif
y', 'vettam', 'wah', 'wait', 'waiting', 'wales', 'wan', 'want', 'wanted', 'w
ap', 'wat', 'watching', 'watts', 'way', 'weak', 'week', 'weekend', 'well',
'wen', 'wet', 'whole', 'wif', 'win', 'wings', 'winner', 'wk', 'wkly', 'wo',
'wonderful', 'wont', 'word', 'words', 'work', 'world', 'worried', 'wow', 'wu
n', 'www', 'xuhui', 'xx', 'xxx', 'xxxmobilemovieclub', 'yeah', 'year', 'ye
s', 'yesterday', 'yo', 'yummy', 'yup', 'ú1']
934
```

Let's create a bag of words model on the spam dataset.

In [41]:

```
# Load data
spam = pd.read_csv("SMSSpamCollection_bow.txt", sep = "\t", names=["label", "message"])
spam.head()
```

Out[41]:

	label	message
0	ham	Go until jurong point, crazy.. Available only in bugis n great world la e buffet... Cine there g...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Text FA to 87121 to receive ...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives around here though

Let's take a subset of data (first 50 rows only) and create bag of word model on that.

In [42]:

```
spam = spam.iloc[0:100,:]
print(spam)
```

```
   label  \
0    ham
1    ham
2   spam
3    ham
4    ham
5   spam
6    ham
7    ham
8   spam
9   spam
10   ham
11  spam
12  spam
13   ham
14   ham
15  spam
16   ham
17   ham
```

In [43]:

```
# extract the messages from the dataframe
messages = spam.message
print(messages)
```

```
0     Go until jurong point, crazy.. Available only in bugis n great worl
d la e buffet... Cine there g...
1
Ok lar... Joking wif u oni...
2     Free entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005.
Text FA to 87121 to receive ...
3                                                   U dun say so earl
y hor... U c already then say...
4                                        Nah I don't think he goes to
usf, he lives around here though
5     FreeMsg Hey there darling it's been 3 week's now and no word back!
I'd like some fun you up for ...
6                           Even my brother is not like to speak with me.
They treat me like aids patent.
7     As per your request 'Melle Melle (Oru Minnaminunginte Nurungu Vetta
m)' has been set as your call...
8     WINNER!! As a valued network customer you have been selected to rec
eivea £900 prize reward! To c...
9     Had your mobile 11 months or more? U R entitled to Update to the la
```

In [44]:

```
# convert messages into list
messages = [message for message in messages]
print(messages)
```

```
['Go until jurong point, crazy.. Available only in bugis n great world la e
buffet... Cine there got amore wat...', 'Ok lar... Joking wif u oni...', "Fr
ee entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Text FA to
87121 to receive entry question(std txt rate)T&C's apply 08452810075over1
8's", 'U dun say so early hor... U c already then say...', "Nah I don't thin
k he goes to usf, he lives around here though", "FreeMsg Hey there darling i
t's been 3 week's now and no word back! I'd like some fun you up for it stil
l? Tb ok! XxX std chgs to send, £1.50 to rcv", 'Even my brother is not like
to speak with me. They treat me like aids patent.', "As per your request 'Me
lle Melle (Oru Minnaminunginte Nurungu Vettam)' has been set as your callert
une for all Callers. Press *9 to copy your friends Callertune", 'WINNER!! As
a valued network customer you have been selected to receivea £900 prize rewa
rd! To claim call 09061701461. Claim code KL341. Valid 12 hours only.', 'Had
your mobile 11 months or more? U R entitled to Update to the latest colour m
obiles with camera for Free! Call The Mobile Update Co FREE on 08002986030',
"I'm gonna be home soon and i don't want to talk about this stuff anymore to
night, k? I've cried enough today.", 'SIX chances to win CASH! From 100 to 2
0,000 pounds txt> CSH11 and send to 87575. Cost 150p/day, 6days, 16+ TsandCs
apply Reply HL 4 info', 'URGENT! You have won a 1 week FREE membership in ou
r £100,000 Prize Jackpot! Txt the word: CLAIM to No: 81010 T&C www.dbuk.net
LCCLTD POBOX 4403LDNW1A7RW18', "I've been searching for the right words to t
hank you for this breather. I promise i wont take your help for granted and
will fulfil my promise. You have been wonderful and a blessing at all time
s.", 'I HAVE A DATE ON SUNDAY WITH WILL!!', 'XXXMobileMovieClub: To use your
credit, click the WAP link in the next txt message or click here>> http://wa
p. (http://wap.) xxxmobilemovieclub.com?n=QJKGIGHJJGCBL', "Oh k...i'm watchi
ng here:)", 'Eh u remember how 2 spell his name... Yes i did. He v naughty m
ake until i v wet.', 'Fine if that\x92s the way u feel. That\x92s the way it
s gota b', 'England v Macedonia - dont miss the goals/team news. Txt ur nati
onal team to 87077 eg ENGLAND to 87077 Try:WALES, SCOTLAND 4txt/ú1.20 POBOXo
x36504W45WQ 16+', 'Is that seriously how you spell his name?', 'I‘m going to
try for 2 months ha ha only joking', 'So ü pay first lar... Then when is da
 stock comin...', 'Aft i finish my lunch then i go str down lor. Ard 3 smth
 lor. U finish ur lunch already?', 'Ffffffffff. Alright no way I can meet up
with you sooner?', "Just forced myself to eat a slice. I'm really not hungry
tho. This sucks. Mark is getting worried. He knows I'm sick when I turn down
pizza. Lol", 'Lol your always so convincing.', "Did you catch the bus ? Are
 you frying an egg ? Did you make a tea? Are you eating your mom's left over
dinner ? Do you feel my Love ?", "I'm back &amp;amp; we're packing the car now,
 I'll let you know if there's room", 'Ahhh. Work. I vaguely remember that! W
hat does it feel like? Lol', "Wait that's still not all that clear, were you
not sure about me being sarcastic or that that's why x doesn't want to live
 with us", "Yeah he got in at 2 and was v apologetic. n had fallen out and s
he was actin like spoilt child and he got caught up in that. Till 2! But we
 won't go there! Not doing too badly cheers. You? ", 'K tell me anything abo
ut you.', 'For fear of fainting with the of all that housework you just did?
Quick have a cuppa', 'Thanks for your subscription to Ringtone UK your mobil
e will be charged £5/month Please confirm by replying YES or NO. If you repl
y NO you will not be charged', 'Yup... Ok i go home look at the timings then
i msg ü again... Xuhui going to learn on 2nd may too but her lesson is at 8a
m', "Oops, I'll let you know when my roommate's done", 'I see the letter B o
n my car', 'Anything lor... U decide...', "Hello! How's you and how did satu
```

```
rday go? I was just texting to see if you'd decided to do anything tomo. Not
that i'm trying to invite myself or anything!", 'Pls go ahead with watts. I
 just wanted to be sure. Do have a great weekend. Abiola', 'Did I forget to
 tell you ? I want you , I need you, I crave you ... But most of all ... I l
ove you my sweet Arabian steed ... Mmmmmm ... Yummy', '07732584351 - Rodger
 Burns - MSG = We tried to call you re your reply to our sms for a free noki
a mobile + free camcorder. Please call now 08000930705 for delivery tomorro
w', 'WHO ARE YOU SEEING?', 'Great! I hope you like your man well endowed. I
 am  &lt;#&gt;  inches...', 'No calls..messages..missed calls', "Didn't you
 get hep b immunisation in nigeria.", 'Fair enough, anything going on?', "Ye
ah hopefully, if tyler can't do it I could maybe ask around a bit", "U don't
know how stubborn I am. I didn't even want to go to the hospital. I kept tel
ling Mark I'm not a weak sucker. Hospitals are for weak suckers.", 'What you
thinked about me. First time you saw me in class.', 'A gram usually runs lik
e  &lt;#&gt; , a half eighth is smarter though and gets you almost a whole s
econd gram for  &lt;#&gt;', "K fyi x has a ride early tomorrow morning but h
e's crashing at our place tonight", 'Wow. I never realized that you were so
 embarassed by your accomodations. I thought you liked it, since i was doing
the best i could and you always seemed so happy about "the cave". I\'m sorry
I didn\'t and don\'t have more to give. I\'m sorry i offered. I\'m sorry you
r room was so embarassing.', 'SMS. ac Sptv: The New Jersey Devils and the De
troit Red Wings play Ice Hockey. Correct or Incorrect? End? Reply END SPTV',
'Do you know what Mallika Sherawat did yesterday? Find out now @  &lt;URL&g
t;', 'Congrats! 1 year special cinema pass for 2 is yours. call 09061209465
 now! C Suprman V, Matrix3, StarWars3, etc all 4 FREE! bx420-ip4-5we. 150pm.
Dont miss out! ', "Sorry, I'll call later in meeting.", 'Tell where you reac
hed', 'Yes..gauti and sehwag out of odi series.', "Your gonna have to pick u
p a $1 burger for yourself on your way home. I can't even move. Pain is kill
ing me.", 'Ha ha ha good joke. Girls are situation seekers.', 'Its a part of
checking IQ', 'Sorry my roommates took forever, it ok if I come by now?', 'O
k lar i double check wif da hair dresser already he said wun cut v short. He
said will cut until i look nice.', 'As a valued customer, I am pleased to ad
vise you that following recent review of your Mob No. you are awarded with a
£1500 Bonus Prize, call 09066364589', 'Today is "song dedicated day.." Which
song will u dedicate for me? Send this to all ur valuable frnds but first rp
ly me...', 'Urgent UR awarded a complimentary trip to EuroDisinc Trav, Aco&E
ntry41 Or £1000. To claim txt DIS to 87121 18+6*£1.50(moreFrmMob. ShrAcomOrS
glSuplt)10, LS1 3AJ', 'Did you hear about the new "Divorce Barbie"? It comes
with all of Ken\'s stuff!', 'I plane to give on this month end.', 'Wah lucky
man... Then can save money... Hee...', 'Finished class where are you.', 'HI
 BABE IM AT HOME NOW WANNA DO SOMETHING? XX', 'K..k:)where are you?how did y
ou performed?', 'U can call me now...', 'I am waiting machan. Call me once y
ou free.', 'Thats cool. i am a gentleman and will treat you with dignity and
respect.', 'I like you peoples very much:) but am very shy pa.', 'Does not o
perate after  &lt;#&gt;  or what', "Its not the same here. Still looking for
a job. How much do Ta's earn there.", "Sorry, I'll call later", 'K. Did you
 call me just now ah? ', 'Ok i am on the way to home hi hi', 'You will be in
the place of that man', 'Yup next stop.', "I call you later, don't have netw
ork. If urgnt, sms me.", "For real when u getting on yo? I only need 2 more
 tickets and one more jacket and I'm done. I already used all my multis.",
 "Yes I started to send requests to make it but pain came back so I'm back i
n bed. Double coins at the factory too. I gotta cash in all my nitros.",
 "I'm really not up to it still tonight babe", 'Ela kano.,il download, come
 wen ur free..', 'Yeah do! Don‘t stand to close tho- you‘ll catch somethin
g!', "Sorry to be a pain. Is it ok if we meet another night? I spent late af
ternoon in casualty and that means i haven't done any of y stuff42moro and t
hat includes all my time sheets and that. Sorry. ", 'Smile in Pleasure Smile
in Pain Smile when trouble pours like Rain Smile when sum1 Hurts U Smile bec
oz SOMEONE still Loves to see u Smiling!!', 'Please call our customer servic
e representative on 0800 169 6031 between 10am-9pm as you have WON a guarant
eed £1000 cash or £5000 prize!', 'Havent planning to buy later. I check alre
```

```
ady lido only got 530 show in e afternoon. U finish work already?', 'Your fr
ee ringtone is waiting to be collected. Simply text the password "MIX" to 85
069 to verify. Get Usher and Britney. FML, PO Box 5249, MK17 92H. 450Ppw 1
6', 'Watching telugu movie..wat abt u?', 'i see. When we finish we have load
s of loans to pay', 'Hi. Wk been ok - on hols now! Yes on for a bit of a ru
n. Forgot that i have hairdressers appointment at four so need to get home n
shower beforehand. Does that cause prob for u?"', 'I see a cup of coffee ani
mation']
```

In [45]:

```
# preprocess messages using the preprocess function
messages = [preprocess(message) for message in messages]
print(messages)
```

```
['go jurong point , crazy.. available bugis n great world la e buffet ... ci
ne got amore wat ...', 'ok lar ... joking wif u oni ...', "free entry 2 wkly
comp win fa cup final tkts 21st may 2005. text fa 87121 receive entry questi
on ( std txt rate ) & c 's apply 08452810075over18 's", 'u dun say early hor
... u c already say ...', "nah n't think goes usf , lives around though", "f
reemsg hey darling 's 3 week 's word back ! 'd like fun still ? tb ok ! xxx
std chgs send , £1.50 rcv", 'even brother like speak . treat like aids paten
t .', "per request 'melle melle ( oru minnaminunginte nurungu vettam ) ' set
callertune callers . press *9 copy friends callertune", 'winner ! ! valued n
etwork customer selected receivea £900 prize reward ! claim call 0906170146
1. claim code kl341 . valid 12 hours .', 'mobile 11 months ? u r entitled up
date latest colour mobiles camera free ! call mobile update co free 08002986
030', "'m gon na home soon n't want talk stuff anymore tonight , k ? 've cri
ed enough today .", 'six chances win cash ! 100 20,000 pounds txt > csh11 se
nd 87575. cost 150p/day , 6days , 16+ tsandcs apply reply hl 4 info', 'urgen
t ! 1 week free membership £100,000 prize jackpot ! txt word : claim : 81010
& c www.dbuk.net lccltd pobox 4403ldnw1a7rw18', "'ve searching right words t
hank breather . promise wont take help granted fulfil promise . wonderful bl
essing times .", 'date sunday ! !', 'xxxmobilemovieclub : use credit , click
wap link next txt message click > > http : //wap . xxxmobilemovieclub.com ?
n=qjkgighjjgcbl', "oh k ... 'm watching : )", 'eh u remember 2 spell name
... yes . v naughty make v wet .', 'fine that\x92s way u feel . that\x92s wa
y gota b', 'england v macedonia - dont miss goals/team news . txt ur nationa
l team 87077 eg england 87077 try : wales , scotland 4txt/ú1.20 poboxox36504
w45wq 16+', 'seriously spell name ?', '‘ going try 2 months ha ha joking',
'ü pay first lar ... da stock comin ...', 'aft finish lunch go str lor . ard
3 smth lor . u finish ur lunch already ?', 'fffffffff . alright way meet so
oner ?', "forced eat slice . 'm really hungry tho . sucks . mark getting wor
ried . knows 'm sick turn pizza . lol", 'lol always convincing .', "catch bu
s ? frying egg ? make tea ? eating mom 's left dinner ? feel love ?", "'m ba
ck & amp ; 're packing car , 'll let know 's room", 'ahhh . work . vaguely r
emember ! feel like ? lol', "wait 's still clear , sure sarcastic 's x n't w
ant live us", "yeah got 2 v apologetic . n fallen actin like spoilt child go
t caught . till 2 ! wo n't go ! badly cheers . ?", 'k tell anything .', 'fea
r fainting housework ? quick cuppa', 'thanks subscription ringtone uk mobile
charged £5/month please confirm replying yes . reply charged', 'yup ... ok g
o home look timings msg ü ... xuhui going learn 2nd may lesson 8am', "oops ,
'll let know roommate 's done", 'see letter b car', 'anything lor ... u deci
de ...', "hello ! 's saturday go ? texting see 'd decided anything tomo . 'm
trying invite anything !", 'pls go ahead watts . wanted sure . great weekend
. abiola', 'forget tell ? want , need , crave ... ... love sweet arabian ste
ed ... mmmmmm ... yummy', '07732584351 - rodger burns - msg = tried call rep
ly sms free nokia mobile + free camcorder . please call 08000930705 delivery
tomorrow', 'seeing ?', 'great ! hope like man well endowed . & lt ; # & gt ;
inches ...', 'calls..messages..missed calls', "n't get hep b immunisation ni
geria .", 'fair enough , anything going ?', "yeah hopefully , tyler ca n't c
ould maybe ask around bit", "u n't know stubborn . n't even want go hospital
. kept telling mark 'm weak sucker . hospitals weak suckers .", 'thinked . f
irst time saw class .', 'gram usually runs like & lt ; # & gt ; , half eight
h smarter though gets almost whole second gram & lt ; # & gt ;', "k fyi x ri
de early tomorrow morning 's crashing place tonight", "wow . never realized
embarassed accomodations . thought liked , since best could always seemed ha
```

```
ppy `` cave '' . 'm sorry n't n't give . 'm sorry offered . 'm sorry room em
barassing .", 'sms . ac sptv : new jersey devils detroit red wings play ice
hockey . correct incorrect ? end ? reply end sptv', 'know mallika sherawat y
esterday ? find @ & lt ; url & gt ;', 'congrats ! 1 year special cinema pass
2 . call 09061209465 ! c suprman v , matrix3 , starwars3 , etc 4 free ! bx42
0-ip4-5we . 150pm . dont miss !', "sorry , 'll call later meeting .", 'tell
reached', 'yes..gauti sehwag odi series .', "gon na pick $ 1 burger way home
. ca n't even move . pain killing .", 'ha ha ha good joke . girls situation
seekers .', 'part checking iq', 'sorry roommates took forever , ok come ?',
'ok lar double check wif da hair dresser already said wun cut v short . said
cut look nice .', 'valued customer , pleased advise following recent review
mob . awarded £1500 bonus prize , call 09066364589', "today `` song dedicate
d day.. '' song u dedicate ? send ur valuable frnds first rply ...", 'urgent
ur awarded complimentary trip eurodisinc trav , aco & entry41 £1000 . claim
txt dis 87121 18+6*£1.50 ( morefrmmob . shracomorsglsuplt ) 10 , ls1 3aj',
"hear new `` divorce barbie '' ? comes ken 's stuff !", 'plane give month en
d .', 'wah lucky man ... save money ... hee ...', 'finished class .', 'hi ba
be im home wan na something ? xx', 'k..k : ) ? performed ?', 'u call ...',
'waiting machan . call free .', 'thats cool . gentleman treat dignity respec
t .', 'like peoples much : ) shy pa .', 'operate & lt ; # & gt ;', ". still
looking job . much ta 's earn .", "sorry , 'll call later", 'k. call ah ?',
'ok way home hi hi', 'place man', 'yup next stop .', "call later , n't netwo
rk . urgnt , sms .", "real u getting yo ? need 2 tickets one jacket 'm done
. already used multis .", "yes started send requests make pain came back 'm
back bed . double coins factory . got ta cash nitros .", "'m really still to
night babe", 'ela kano. , il download , come wen ur free..', 'yeah ! ‘ stand
close tho- ‘ catch something !', "sorry pain . ok meet another night ? spent
late afternoon casualty means n't done stuff42moro includes time sheets . so
rry .", 'smile pleasure smile pain smile trouble pours like rain smile sum1
hurts u smile becoz someone still loves see u smiling ! !', 'please call cus
tomer service representative 0800 169 6031 10am-9pm guaranteed £1000 cash £5
000 prize !', 'havent planning buy later . check already lido got 530 show e
afternoon . u finish work already ?', "free ringtone waiting collected . sim
ply text password `` mix '' 85069 verify . get usher britney . fml , po box
5249 , mk17 92h . 450ppw 16", 'watching telugu movie..wat abt u ?', 'see . f
inish loads loans pay', "hi . wk ok - hols ! yes bit run . forgot hairdresse
rs appointment four need get home n shower beforehand . cause prob u ? ''",
'see cup coffee animation']
```

In [46]:

```
# bag of words model
vectorizer = CountVectorizer()
bow_model = vectorizer.fit_transform(messages)
print(bow_model.toarray())
```

```
[[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]]
```

In [47]:

```
print(bow_model.shape)
print(vectorizer.get_feature_names())
```

```
(100, 640)
['000', '07732584351', '0800', '08000930705', '08002986030', '08452810075ove
r18', '09061209465', '09061701461', '09066364589', '10', '100', '1000', '10a
m', '11', '12', '1500', '150p', '150pm', '16', '169', '18', '20', '2005', '2
1st', '2nd', '3aj', '4403ldnw1a7rw18', '450ppw', '4txt', '50', '5000', '524
9', '530', '5we', '6031', '6days', '81010', '85069', '87077', '87121', '8757
5', '8am', '900', '92h', '9pm', 'abiola', 'abt', 'ac', 'accomodations', 'ac
o', 'actin', 'advise', 'aft', 'afternoon', 'ah', 'ahead', 'ahhh', 'aids', 'a
lmost', 'already', 'alright', 'always', 'amore', 'amp', 'animation', 'anothe
r', 'anymore', 'anything', 'apologetic', 'apply', 'appointment', 'arabian',
'ard', 'around', 'ask', 'available', 'awarded', 'babe', 'back', 'badly', 'ba
rbie', 'becoz', 'bed', 'beforehand', 'best', 'bit', 'blessing', 'bonus', 'bo
x', 'breather', 'britney', 'brother', 'buffet', 'bugis', 'burger', 'burns',
'bus', 'buy', 'bx420', 'ca', 'call', 'callers', 'callertune', 'calls', 'camc
order', 'came', 'camera', 'car', 'cash', 'casualty', 'catch', 'caught', 'cau
se', 'cave', 'chances', 'charged', 'check', 'checking', 'cheers', 'chgs', 'c
hild', 'cine', 'cinema', 'claim', 'class', 'clear', 'click', 'close', 'co',
'code', 'coffee', 'coins', 'collected', 'colour', 'com', 'come', 'comes', 'c
omin', 'comp', 'complimentary', 'confirm', 'congrats', 'convincing', 'cool',
'copy', 'correct', 'cost', 'could', 'crashing', 'crave', 'crazy', 'credit',
'cried', 'csh11', 'cup', 'cuppa', 'customer', 'cut', 'da', 'darling', 'dat
e', 'day', 'dbuk', 'decide', 'decided', 'dedicate', 'dedicated', 'delivery',
'detroit', 'devils', 'dignity', 'dinner', 'dis', 'divorce', 'done', 'dont',
'double', 'download', 'dresser', 'dun', 'early', 'earn', 'eat', 'eating', 'e
g', 'egg', 'eh', 'eighth', 'ela', 'embarassed', 'embarassing', 'end', 'endow
ed', 'england', 'enough', 'entitled', 'entry', 'entry41', 'etc', 'eurodisin
c', 'even', 'fa', 'factory', 'fainting', 'fair', 'fallen', 'fear', 'feel',
'fffffffff', 'final', 'find', 'fine', 'finish', 'finished', 'first', 'fml',
'following', 'forced', 'forever', 'forget', 'forgot', 'four', 'free', 'freem
sg', 'friends', 'frnds', 'frying', 'fulfil', 'fun', 'fyi', 'gauti', 'gentlem
an', 'get', 'gets', 'getting', 'girls', 'give', 'go', 'goals', 'goes', 'goin
g', 'gon', 'good', 'got', 'gota', 'gram', 'granted', 'great', 'gt', 'guarant
eed', 'ha', 'hair', 'hairdressers', 'half', 'happy', 'havent', 'hear', 'he
e', 'hello', 'help', 'hep', 'hey', 'hi', 'hl', 'hockey', 'hols', 'home', 'ho
pe', 'hopefully', 'hor', 'hospital', 'hospitals', 'hours', 'housework', 'htt
p', 'hungry', 'hurts', 'ice', 'il', 'im', 'immunisation', 'inches', 'include
s', 'incorrect', 'info', 'invite', 'ip4', 'iq', 'jacket', 'jackpot', 'jerse
y', 'job', 'joke', 'joking', 'jurong', 'kano', 'ken', 'kept', 'killing', 'kl
341', 'know', 'knows', 'la', 'lar', 'late', 'later', 'latest', 'lccltd', 'le
arn', 'left', 'lesson', 'let', 'letter', 'lido', 'like', 'liked', 'link', 'l
ive', 'lives', 'll', 'loads', 'loans', 'lol', 'look', 'looking', 'lor', 'lov
e', 'loves', 'ls1', 'lt', 'lucky', 'lunch', 'macedonia', 'machan', 'make',
'mallika', 'man', 'mark', 'matrix3', 'may', 'maybe', 'means', 'meet', 'meeti
ng', 'melle', 'membership', 'message', 'messages', 'minnaminunginte', 'mis
s', 'missed', 'mix', 'mk17', 'mmmmmm', 'mob', 'mobile', 'mobiles', 'mom', 'm
oney', 'month', 'months', 'morefrmmob', 'morning', 'move', 'movie', 'msg',
'much', 'multis', 'na', 'nah', 'name', 'national', 'naughty', 'need', 'net',
'network', 'never', 'new', 'news', 'next', 'nice', 'nigeria', 'night', 'nitr
os', 'nokia', 'nurungu', 'odi', 'offered', 'oh', 'ok', 'one', 'oni', 'oops',
'operate', 'oru', 'pa', 'packing', 'pain', 'part', 'pass', 'password', 'pate
nt', 'pay', 'peoples', 'per', 'performed', 'pick', 'pizza', 'place', 'plan
e', 'planning', 'play', 'please', 'pleased', 'pleasure', 'pls', 'po', 'pobo
x', 'poboxox36504w45wq', 'point', 'pounds', 'pours', 'press', 'prize', 'pro
```

```
b', 'promise', 'qjkgighjjgcbl', 'question', 'quick', 'rain', 'rate', 'rcv',
're', 'reached', 'real', 'realized', 'really', 'receive', 'receivea', 'recen
t', 'red', 'remember', 'reply', 'replying', 'representative', 'request', 're
quests', 'respect', 'review', 'reward', 'ride', 'right', 'ringtone', 'rodge
r', 'room', 'roommate', 'roommates', 'rply', 'run', 'runs', 'said', 'sarcast
ic', 'saturday', 'save', 'saw', 'say', 'scotland', 'searching', 'second', 's
ee', 'seeing', 'seekers', 'seemed', 'sehwag', 'selected', 'send', 'series',
'seriously', 'service', 'set', 'sheets', 'sherawat', 'short', 'show', 'showe
r', 'shracomorsglsuplt', 'shy', 'sick', 'simply', 'since', 'situation', 'si
x', 'slice', 'smarter', 'smile', 'smiling', 'sms', 'smth', 'someone', 'somet
hing', 'song', 'soon', 'sooner', 'sorry', 'speak', 'special', 'spell', 'spen
t', 'spoilt', 'sptv', 'stand', 'started', 'starwars3', 'std', 'steed', 'stil
l', 'stock', 'stop', 'str', 'stubborn', 'stuff', 'stuff42moro', 'subscriptio
n', 'sucker', 'suckers', 'sucks', 'sum1', 'sunday', 'suprman', 'sure', 'swee
t', 'ta', 'take', 'talk', 'tb', 'tea', 'team', 'tell', 'telling', 'telugu',
'text', 'texting', 'thank', 'thanks', 'that', 'thats', 'think', 'thinked',
'tho', 'though', 'thought', 'tickets', 'till', 'time', 'times', 'timings',
'tkts', 'today', 'tomo', 'tomorrow', 'tonight', 'took', 'trav', 'treat', 'tr
ied', 'trip', 'trouble', 'try', 'trying', 'tsandcs', 'turn', 'txt', 'tyler',
'uk', 'update', 'ur', 'urgent', 'urgnt', 'url', 'us', 'use', 'used', 'usf',
'usher', 'usually', 'vaguely', 'valid', 'valuable', 'valued', 've', 'verif
y', 'vettam', 'wah', 'wait', 'waiting', 'wales', 'wan', 'want', 'wanted', 'w
ap', 'wat', 'watching', 'watts', 'way', 'weak', 'week', 'weekend', 'well',
'wen', 'wet', 'whole', 'wif', 'win', 'wings', 'winner', 'wk', 'wkly', 'wo',
'wonderful', 'wont', 'word', 'words', 'work', 'world', 'worried', 'wow', 'wu
n', 'www', 'xuhui', 'xx', 'xxx', 'xxxmobilemovieclub', 'yeah', 'year', 'ye
s', 'yesterday', 'yo', 'yummy', 'yup', 'ú1']
```

In [48]:

```
# Look at the dataframe
pd.DataFrame(bow_model.toarray(), columns = vectorizer.get_feature_names())
```

Out[48]:

	000	07732584351	0800	08000930705	08002986030	08452810075over18	09061209465	0906
0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	
2	0	0	0	0	0	1	0	
3	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	
9	0	0	0	0	1	0	0	
10	0	0	0	0	0	0	0	
11	1	0	0	0	0	0	0	
12	1	0	0	0	0	0	0	
13	0	0	0	0	0	0	0	
14	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	
16	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	
...	...	...	...	...	...	...	...	
70	0	0	0	0	0	0	0	

	000	07732584351	0800	08000930705	08002986030	08452810075over18	09061209465	0906
71	0	0	0	0	0	0	0	
72	0	0	0	0	0	0	0	
73	0	0	0	0	0	0	0	
74	0	0	0	0	0	0	0	
75	0	0	0	0	0	0	0	
76	0	0	0	0	0	0	0	
77	0	0	0	0	0	0	0	
78	0	0	0	0	0	0	0	
79	0	0	0	0	0	0	0	
80	0	0	0	0	0	0	0	
81	0	0	0	0	0	0	0	
82	0	0	0	0	0	0	0	
83	0	0	0	0	0	0	0	
84	0	0	0	0	0	0	0	
85	0	0	0	0	0	0	0	
86	0	0	0	0	0	0	0	
87	0	0	0	0	0	0	0	
88	0	0	0	0	0	0	0	
89	0	0	0	0	0	0	0	
90	0	0	0	0	0	0	0	
91	0	0	0	0	0	0	0	
92	0	0	0	0	0	0	0	
93	0	0	1	0	0	0	0	
94	0	0	0	0	0	0	0	
95	0	0	0	0	0	0	0	
96	0	0	0	0	0	0	0	
97	0	0	0	0	0	0	0	
98	0	0	0	0	0	0	0	
99	0	0	0	0	0	0	0	

100 rows × 640 columns

To build a bag-of-words model in Python, you can use the scikit-learn library. As you saw, you get lots of redundant features after building the model. There were features such as ‘get’ and ‘getting’, ‘goes’ and ‘going’, ‘see’ and ‘seeing’ and along with a lot of other duplicate features. They are not exactly duplicates but they’re redundant in the sense that they’re not giving you any extra information about the message. In fact, the words ‘winner’ and ‘win’ are equivalent when your goal is to detect whether a message is spam or not.

Hence, keeping the two separate is actually going to hinder the performance of the machine learning algorithm since it is redundant information. Also, this redundancy is going to increase the number of features due to which the classifier can face the curse of dimensionality. To get rid of this problem, you’re going to learn two more

preprocessing techniques - stemming and lemmatization - in the next section.

In the next section, you'll learn about preprocessing techniques that'll help you to get rid of redundant tokens or features.

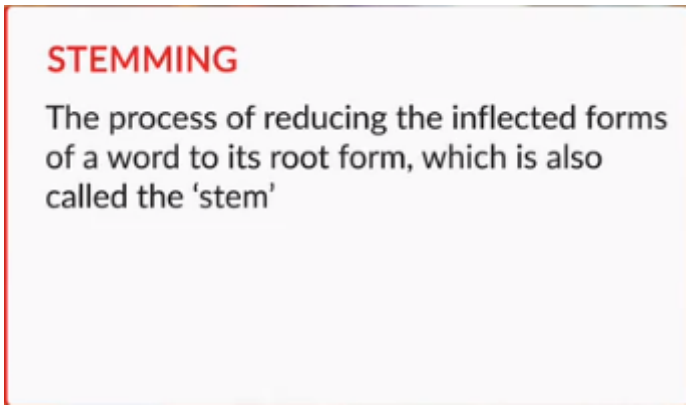
Stemming and Lemmatization

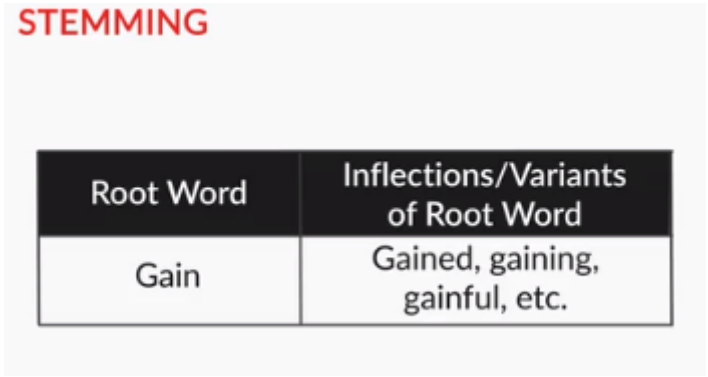
In the last section, you had seen the problem of redundant tokens. This will result in an inefficient model when you build your spam detector. Stemming makes sure that different variations of a word, say 'warm', warmer', 'warming' and 'warmed,' are represented by a single token - 'warm', because they all represent the same information (represented by the 'stem' of the word).

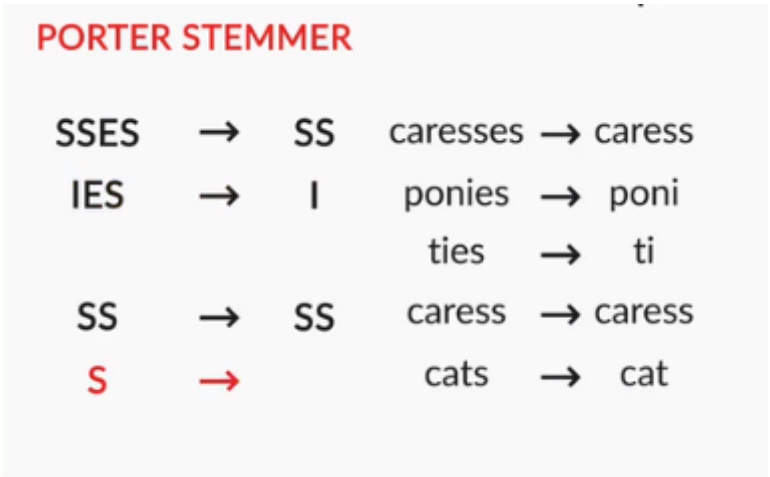
Another similar preprocessing step (and an alternative to stemming) is lemmatisation.

You'll now learn about these two techniques that will help you deal with the problem of redundant tokens:

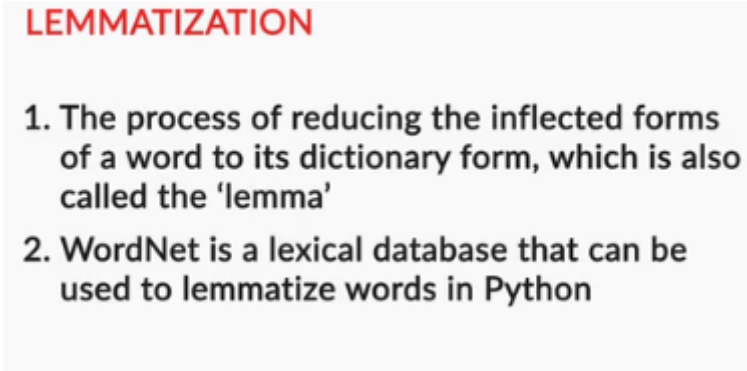
1. Stemming

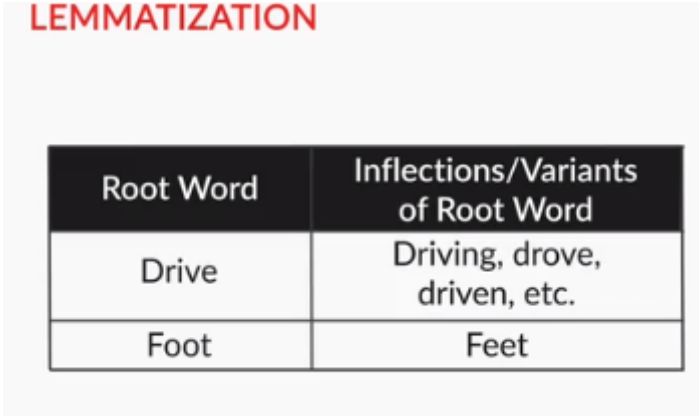






2. Lemmatization





If you noticed, the repeated tokens or features were nothing but a variation or an inflected form of the other token. For example, the word 'seeing' is an inflection of the word 'see'. Similarly, the word 'limited' is an inflection of the word 'limit'. The two techniques that you just learnt reduce these inflected words to the original base form. But which is one is a better technique in what situations? Let's look at them one by one:

Stemming

It is a rule-based technique that just chops off the suffix of a word to get its root form, which is called the 'stem'. For example, if you use a stemmer to stem the words of the string - "The driver is racing in his boss' car", the words 'driver' and 'racing' will be converted to their root form by just chopping of the suffixes 'er' and 'ing'. So, 'driver' will be converted to 'driv' and 'racing' will be converted to 'rac'.

You might think that the root forms (or stems) don't resemble the root words - 'drive' and 'race'. You don't have to worry about this because the stemmer will convert all the variants of 'drive' and 'racing' to those root forms only. So, it will convert 'drive', 'driving', etc. to 'driv', and 'race', 'racer', etc. to 'rac'. This gives us satisfactory results in most cases.

There are two popular stemmers:

1. Porter stemmer: This was developed in 1980 and works only on English words. You can find all the detailed rules of this stemmer here

http://snowball.tartarus.org/algorithms/porter/stemmer.html (http://snowball.tartarus.org/algorithms/porter/stemmer.html)

2. Snowball stemmer: This is a more versatile stemmer that not only works on English words but also on words of other languages such as French, German, Italian, Finnish, Russian, and many more languages. You can learn more about this stemmer here

http://snowball.tartarus.org/ (http://snowball.tartarus.org/) .

Lemmatization

This is a more sophisticated technique (and perhaps more 'intelligent') in the sense that it doesn't just chop off the suffix of a word. Instead, it takes an input word and searches for its base word by going recursively through all the variations of dictionary words. The base word in this case is called the lemma. Words such as 'feet', 'drove', 'arose', 'bought', etc. can't be reduced to their correct base form using a stemmer. But a lemmatizer can reduce them to their correct base form. The most popular lemmatizer is the WordNet lemmatizer created by a team od researchers at the Princeton university. You can read more about it here. https://wordnet.princeton.edu/ (https://wordnet.princeton.edu/)

Nevertheless, you may sometimes find yourself confused in whether to use a stemmer or a lemmatizer in your application. The following points might help you make the decision:

```
1.A stemmer is a rule based technique, and hence, it is much faster than the lemma
tizer (which searches the dictionary to look for the lemma of a word). On the othe
r hand, a stemmer typically gives less accurate results than a lemmatizer.

2.A lemmatizer is slower because of the dictionary lookup but gives better results
than a stemmer. Now, as a side note, it is important to know that for a lemmatizer
to perform accurately, you need to provide the part-of-speech tag of the input wor
d (noun, verb, adjective etc.). You'll see learn POS tagging in the next session -
but it would suffice to know that there are often cases when the POS tagger itself
is quite inaccurate on your text, and that will worsen the performance of the lemm
atiser as well. In short, you may want to consider a stemmer rather than a lemmati
ser if you notice that POS tagging is inaccurate.
```

In general, you can try both and see if its worth using a lemmatizer over a stemmer. If a stemmer is giving you almost same results with increased efficiency than choose a stemmer, otherwise use a lemmatizer.

Description

Write a function which takes an input word and stems it by chopping off its suffix. For the sake of simplicity, consider only words that have the following suffixes:

'ing'

'ed

Sample input: 'playing'

Expected output: 'play'

Tip: Use regular expressions!

In [61]:

```
import re
import ast, sys
word = "played"

# create function to chop off the suffixes 'ing' and 'ed'
def stemmer(word):
    # write your code here
    word = re.sub('(ing|ed)$','',word)
    return word

# stem word -- don't change the following code, it is used to evaluate your code
print(stemmer(word))
```

```
play
```

Stemming

In [62]:

```
# import libraries
import pandas as pd
from nltk.tokenize import word_tokenize
from nltk.stem.porter import PorterStemmer
from nltk.stem.snowball import SnowballStemmer
```

In [63]:

```
text = "Very orderly and methodical he looked, with a hand on each knee, and a loud watch t
print(text)
```

```
Very orderly and methodical he looked, with a hand on each knee, and a loud
watch ticking a sonorous sermon under his flapped newly bought waist-coat, a
s though it pitted its gravity and longevity against the levity and evanesce
nce of the brisk fire.
```

In [64]:

```
tokens = word_tokenize(text.lower())
print(tokens)
```

```
['very', 'orderly', 'and', 'methodical', 'he', 'looked', ',', 'with', 'a',
'hand', 'on', 'each', 'knee', ',', 'and', 'a', 'loud', 'watch', 'ticking',
'a', 'sonorous', 'sermon', 'under', 'his', 'flapped', 'newly', 'bought', 'wa
ist-coat', ',', 'as', 'though', 'it', 'pitted', 'its', 'gravity', 'and', 'lo
ngevity', 'against', 'the', 'levity', 'and', 'evanescence', 'of', 'the', 'br
isk', 'fire', '.']
```

In [65]:

```
stemmer = PorterStemmer()
porter_stemmed = [stemmer.stem(token) for token in tokens]
print(porter_stemmed)
len(porter_stemmed)
```

```
['veri', 'orderli', 'and', 'method', 'he', 'look', ',', 'with', 'a', 'hand',
'on', 'each', 'knee', ',', 'and', 'a', 'loud', 'watch', 'tick', 'a', 'sono
r', 'sermon', 'under', 'hi', 'flap', 'newli', 'bought', 'waist-coat', ',',
'as', 'though', 'it', 'pit', 'it', 'graviti', 'and', 'longev', 'against', 't
he', 'leviti', 'and', 'evanesc', 'of', 'the', 'brisk', 'fire', '.']
```

Out[65]:

```
47
```

In [70]:

```
# snowball stemmer
stemmer = SnowballStemmer("english")
snowball_stemmed = [stemmer.stem(token) for token in tokens]
print(snowball_stemmed)
len(snowball_stemmed)
```

```
['veri', 'order', 'and', 'method', 'he', 'look', ',', 'with', 'a', 'hand',
'on', 'each', 'knee', ',', 'and', 'a', 'loud', 'watch', 'tick', 'a', 'sono
r', 'sermon', 'under', 'his', 'flap', 'newli', 'bought', 'waist-coat', ',',
'as', 'though', 'it', 'pit', 'it', 'graviti', 'and', 'longev', 'against', 't
he', 'leviti', 'and', 'evanesc', 'of', 'the', 'brisk', 'fire', '.']
```

Out[70]:

```
47
```

In [72]:

```
df = pd.DataFrame({'token': tokens, 'porter_stemmed': porter_stemmed, 'snowball_stemmed': s
df = df[['token', 'porter_stemmed', 'snowball_stemmed']]
```

In [73]:

```
df[(df.token != df.porter_stemmed) | (df.token != df.snowball_stemmed)]
```

Out[73]:

	token	porter_stemmed	snowball_stemmed
0	very	veri	veri
1	orderly	orderli	order
3	methodical	method	method
5	looked	look	look
18	ticking	tick	tick
20	sonorous	sonor	sonor
23	his	hi	his
24	flapped	flap	flap
25	newly	newli	newli
32	pitted	pit	pit

You learnt to use two types of stemmers - the Porter stemmer and the Snowball stemmer. Snowball stemmer works a little better, but usually, you won't see much of a difference as both of them are rule based. Snowball has some updated rules and that's why you saw it stems some words differently. Practice your stemming skills in the following exercise.

Description

Use Porter stemmer to stem a given word

Sample input: Gardening

Expected output: Garden

In [76]:

```
from nltk.tokenize import word_tokenize
from nltk.stem.porter import PorterStemmer
import ast, sys
word = 'coming'

# instantiate porter stemmer
stemmer = PorterStemmer()# write code here

# stem word
stemmed = stemmer.stem(word)# write your code here

# print stemmed word -- don't change the following code, it is used to evaluate your code
print(stemmed)
```

```
come
```

Description

Stem a given word using Snowball stemmer.

Sample input: coming

Expected output: come

In [75]:

```
from nltk.tokenize import word_tokenize
from nltk.stem.snowball import SnowballStemmer
import ast, sys
word = "coming"

# instantiate porter stemmer
stemmer = SnowballStemmer("english")# write code here

# stem word
stemmed = stemmer.stem(word)# write code here

# print stemmed word -- don't change the following code, it is used to evaluate your code
print(stemmed)
```

```
come
```

Lemmatization

In [77]:

```
### import necessary libraries
from nltk.stem import WordNetLemmatizer
from nltk.tokenize import word_tokenize
```

In [78]:

```
text = "Very orderly and methodical he looked, with a hand on each knee, and a loud watch t
print(text)
```

```
Very orderly and methodical he looked, with a hand on each knee, and a loud
watch ticking a sonorous sermon under his flapped newly bought waist-coat, a
s though it pitted its gravity and longevity against the levity and evanesce
nce of the brisk fire.
```

In [79]:

```
# tokenise text
tokens = word_tokenize(text)
```

In [80]:

```
wordnet_lemmatizer = WordNetLemmatizer()
lemmatized = [wordnet_lemmatizer.lemmatize(token) for token in tokens]
print(lemmatized)
```

```
['Very', 'orderly', 'and', 'methodical', 'he', 'looked', ',', 'with', 'a',
'hand', 'on', 'each', 'knee', ',', 'and', 'a', 'loud', 'watch', 'ticking',
'a', 'sonorous', 'sermon', 'under', 'his', 'flapped', 'newly', 'bought', 'wa
ist-coat', ',', 'a', 'though', 'it', 'pitted', 'it', 'gravity', 'and', 'long
evity', 'against', 'the', 'levity', 'and', 'evanescence', 'of', 'the', 'bris
k', 'fire', '.']
```

Let's compare stemming and lemmatization

In [81]:

```
from nltk.stem.porter import PorterStemmer
stemmer = PorterStemmer()
stemmed = [stemmer.stem(token) for token in tokens]
print(stemmed)
```

```
['veri', 'orderli', 'and', 'method', 'he', 'look', ',', 'with', 'a', 'hand',
'on', 'each', 'knee', ',', 'and', 'a', 'loud', 'watch', 'tick', 'a', 'sono
r', 'sermon', 'under', 'hi', 'flap', 'newli', 'bought', 'waist-coat', ',',
'as', 'though', 'it', 'pit', 'it', 'graviti', 'and', 'longev', 'against', 't
he', 'leviti', 'and', 'evanesc', 'of', 'the', 'brisk', 'fire', '.']
```

In [82]:

```
import pandas as pd
df = pd.DataFrame(data={'token': tokens, 'stemmed': stemmed, 'lemmatized': lemmatized})
df = df[['token', 'stemmed', 'lemmatized']]
df[(df.token != df.stemmed) | (df.token != df.lemmatized)]
```

Out[82]:

	token	stemmed	lemmatized
0	Very	veri	Very
1	orderly	orderli	orderly
3	methodical	method	methodical
5	looked	look	looked
18	ticking	tick	ticking
20	sonorous	sonor	sonorous
23	his	hi	his
24	flapped	flap	flapped
25	newly	newli	newly
29	as	as	a
32	pitted	pit	pitted
33	its	it	it
34	gravity	graviti	gravity
36	longevity	longev	longevity
39	levity	leviti	levity
41	evanescence	evanesc	evanescence

Let's compare the speed of both techniques

In [83]:

```
import requests
url = "https://www.gutenberg.org/files/11/11-0.txt"
alice = requests.get(url)
print(alice.text)
```

```
Project Gutenberg’s Alice’s Adventures in Wonderland, by Lewis Carroll

This eBook is for the use of anyone anywhere at no cost and with
almost no restrictions whatsoever.  You may copy it, give it away or
re-use it under the terms of the Project Gutenberg License included
with this eBook or online at www.gutenberg.org


Title: Alice’s Adventures in Wonderland

Author: Lewis Carroll

Posting Date: June 25, 2008 [EBook #11]
Release Date: March, 1994
Last Updated: October 6, 2016

Language: English

Character set encoding: UTF-8
```

In [84]:

```
wordnet_lemmatizer = WordNetLemmatizer()
wordnet_lemmatizer.lemmatize("having")
```

Out[84]:

```
'having'
```

In [85]:

```
%%time
_ = [wordnet_lemmatizer.lemmatize(token, pos='n') for token in word_tokenize(alice.text)]
```

```
Wall time: 387 ms
```

In [86]:

```
%%time
_ = [stemmer.stem(token) for token in word_tokenize(alice.text)]
```

```
Wall time: 749 ms
```

- Lemmatising is faster than stemming in this case because the nltk lemmatiser also takes another argument called the part-of-speech (POS) tag of the input word.
- The default part-of-speech tag is 'noun'..
- You will learn more about part-of-speech tagging later in this course.
- Right now, the stemmer will have more accuracy than the lemmatiser because each word is lemmatised assuming it's a noun. To lemmatise efficiently, you need to pass it's POS tag manually.

CLARIFICATION: You observed that in this case, lemmatization was faster than stemming. That's due to the fact that we didn't pass the part-of-speech tag with each word. Because of this, lemmatization happened quickly, but incorrectly. Had we passed the POS tag for each word, lemmatization would have had much more accuracy than stemming, but it would have also taken a lot of time.

You'll see how to find the POS tag of a word in the second module. Then, you'll be able to pass each word's POS tag along with it to lemmatize it correctly. Practice your lemmatization skills in the following quiz.

Description

Lemmatize a given word (consider verbs only) using the WordNet Lemmatizer.

Sample input: schooling

Expected output: school

In [88]:

```
from nltk.stem import WordNetLemmatizer
import ast, sys
word = 'schooling'

# instantiate wordnet lemmatizer
lemmatizer = WordNetLemmatizer()# write code here

# lemmatize word
lemmatized = lemmatizer.lemmatize(word,pos='v')# write code here. Pass the parameter -> pos

# print lemmatized word -- don't change the following code, it is used to evaluate your coa
print(lemmatized)
```

```
school
```

Final Bag-of-Words Representation

You've learn quite a few techniques in lexical preprocessing, namely:

1.Plotting word frequencies and removing stopwords

2.Tokenisation

3.Stemming

4.Lemmatization

Now, let's create the bag-of-words model, again, but this time, using stemming and lemmatization along with the other preprocessing steps. It will result in reducing the number of features by eliminating redundant features that we had created earlier. But more importantly, will lead to a more efficient representation. You can download the Jupyter notebook that the professor uses here:

You saw how stemming and lemmatization performed on the spam dataset. Lemmatization didn't perform as good as it should have because of two reasons:

- Lemmatization expected the POS tag of the word to be passed along with the word. We didn't pass the POS tag here. You'll learn how to assign POS tags in the next module.
- Lemmatization only works on correctly spelt words. Since there are a lot of misspelt words in the dataset, lemmatization makes no changes to them.

In other words, the comparison of stemming and lemmatization wasn't actually fair. You can redo this comparison when you learn to tag each word with it's POS tag. Then, you can automate the process of lemmatization by passing the word along with it's POS tag. It will be fair to compare the process of stemming and lemmatization only then. The comparison here was just for demonstration purposes.

In the next section, you'll learn a new way to create matrix representation from a text corpus of documents.

Bag of words model

In [89]:

```
# load all necessary libraries
import pandas as pd
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
from sklearn.feature_extraction.text import CountVectorizer

pd.set_option('max_colwidth', 100)
```

Let's build a basic bag of words model on three sample documents

In [91]:

```
documents = ["Gangs of Wasseypur is a great movie.", "The success of a movie depends on the
print(documents)
```

```
['Gangs of Wasseypur is a great movie.', 'The success of a movie depends on
the performance of the actors.', 'There are no new movies releasing this wee
k.']
```

In [92]:

```
def preprocess(document):
    'changes document to lower case and removes stopwords'

    # change sentence to lower case
    document = document.lower()

    # tokenize into words
    words = word_tokenize(document)

    # remove stop words
    words = [word for word in words if word not in stopwords.words("english")]

    # join words to make sentence
    document = " ".join(words)

    return document

documents = [preprocess(document) for document in documents]
print(documents)
```

```
['gangs wasseypur great movie .', 'success movie depends performance actors
.', 'new movies releasing week .']
```

Creating bag of words model using count vectorizer function

In [93]:

```
vectorizer = CountVectorizer()
bow_model = vectorizer.fit_transform(documents)
print(bow_model)  # returns the row number and column number of the cells which have 1 as v
```

```
  (0, 4)        1
  (0, 3)        1
  (0, 10)       1
  (0, 2)        1
  (1, 0)        1
  (1, 7)        1
  (1, 1)        1
  (1, 9)        1
  (1, 4)        1
  (2, 11)       1
  (2, 8)        1
  (2, 5)        1
  (2, 6)        1
```

In [94]:

```
# print the full sparse matrix
print(bow_model.toarray())
```

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

In [95]:

```
print(bow_model.shape)
print(vectorizer.get_feature_names())
```

```
(3, 12)
['actors', 'depends', 'gangs', 'great', 'movie', 'movies', 'new', 'performan
ce', 'releasing', 'success', 'wasseypur', 'week']
```

Let's create a bag of words model on the spam dataset.

In [96]:

```
# Load data
spam = pd.read_csv("SMSSpamCollection_fin.txt", sep = "\t", names=["label", "message"])
spam.head()
```

Out[96]:

	label	message
0	ham	Go until jurong point, crazy.. Available only in bugis n great world la e buffet... Cine there g...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Text FA to 87121 to receive ...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives around here though

Let's take a subset of data (first 50 rows only) and create bag of word model on that.

In [97]:

```
spam = spam.iloc[0:50,:]
print(spam)
```

```
   label  \
0    ham
1    ham
2   spam
3    ham
4    ham
5   spam
6    ham
7    ham
8   spam
9   spam
10   ham
11  spam
12  spam
13   ham
14   ham
15  spam
16   ham
17   ham
```

In [98]:

```
# extract the messages from the dataframe
messages = spam.message
print(messages)
```

```
0     Go until jurong point, crazy.. Available only in bugis n great world l
a e buffet... Cine there g...
1
Ok lar... Joking wif u oni...
2     Free entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Te
xt FA to 87121 to receive ...
3                                                       U dun say so early h
or... U c already then say...
4                                          Nah I don't think he goes to us
f, he lives around here though
5     FreeMsg Hey there darling it's been 3 week's now and no word back! I'd
like some fun you up for ...
6                            Even my brother is not like to speak with me. Th
ey treat me like aids patent.
7     As per your request 'Melle Melle (Oru Minnaminunginte Nurungu Vettam)'
has been set as your call...
8     WINNER!! As a valued network customer you have been selected to receiv
ea £900 prize reward! To c...
9     Had your mobile 11 months or more? U R entitled to Update to the lates
t colour mobiles with came...
10    I'm gonna be home soon and i don't want to talk about this stuff anymo
re tonight, k? I've cried ...
11    SIX chances to win CASH! From 100 to 20,000 pounds txt> CSH11 and send
to 87575. Cost 150p/day, ...
12    URGENT! You have won a 1 week FREE membership in our £100,000 Prize Ja
ckpot! Txt the word: CLAIM...
13    I've been searching for the right words to thank you for this breathe
r. I promise i wont take yo...
14                                                                  I HAVE
A DATE ON SUNDAY WITH WILL!!
15    XXXMobileMovieClub: To use your credit, click the WAP link in the next
txt message or click here...
16
Oh k...i'm watching here:)
17                       Eh u remember how 2 spell his name... Yes i did. He
v naughty make until i v wet.
18                                              Fine if that□s the way u fe
el. That□s the way its gota b
19    England v Macedonia - dont miss the goals/team news. Txt ur national t
eam to 87077 eg ENGLAND to...
20                                                      Is that seri
ously how you spell his name?
21                                                 I‘m going to try f
or 2 months ha ha only joking
22                                              So ü pay first lar... T
hen when is da stock comin...
23               Aft i finish my lunch then i go str down lor. Ard 3 smth lo
r. U finish ur lunch already?
24                                           Fffffffff. Alright no way I
can meet up with you sooner?
25    Just forced myself to eat a slice. I'm really not hungry tho. This suc
ks. Mark is getting worrie...
```

```
26                                                                                                  L
ol your always so convincing.
27    Did you catch the bus ? Are you frying an egg ? Did you make a tea? Ar
e you eating your mom's le...
28                              I'm back &amp;amp; we're packing the car now, I'll
let you know if there's room
29                                          Ahhh. Work. I vaguely remember tha
t! What does it feel like? Lol
30    Wait that's still not all that clear, were you not sure about me being
sarcastic or that that's ...
31    Yeah he got in at 2 and was v apologetic. n had fallen out and she was
actin like spoilt child a...
32
K tell me anything about you.
33                    For fear of fainting with the of all that housework you
just did? Quick have a cuppa
34    Thanks for your subscription to Ringtone UK your mobile will be charge
d £5/month Please confirm ...
35    Yup... Ok i go home look at the timings then i msg ü again... Xuhui go
ing to learn on 2nd may to...
36                                                              Oops, I'll let you
know when my roommate's done
37
I see the letter B on my car
38
Anything lor... U decide...
39    Hello! How's you and how did saturday go? I was just texting to see if
you'd decided to do anyth...
40                       Pls go ahead with watts. I just wanted to be sure. Do
have a great weekend. Abiola
41    Did I forget to tell you ? I want you , I need you, I crave you ... Bu
t most of all ... I love y...
42    07732584351 - Rodger Burns - MSG = We tried to call you re your reply
to our sms for a free noki...
43
WHO ARE YOU SEEING?
44                                 Great! I hope you like your man well endowe
d. I am  &amp;lt;#&amp;gt;  inches...
45                                                                                  No
calls..messages..missed calls
46                                                            Didn't you get h
ep b immunisation in nigeria.
47                                                                                   Fa
ir enough, anything going on?
48                                       Yeah hopefully, if tyler can't do it I
could maybe ask around a bit
49    U don't know how stubborn I am. I didn't even want to go to the hospit
al. I kept telling Mark I'...
Name: message, dtype: object
```

In [99]:

```
# convert messages into list
messages = [message for message in messages]
print(messages)
```

```
['Go until jurong point, crazy.. Available only in bugis n great world la e
buffet... Cine there got amore wat...', 'Ok lar... Joking wif u oni...', "Fr
ee entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Text FA to
87121 to receive entry question(std txt rate)T&C's apply 08452810075over1
8's", 'U dun say so early hor... U c already then say...', "Nah I don't thin
k he goes to usf, he lives around here though", "FreeMsg Hey there darling i
t's been 3 week's now and no word back! I'd like some fun you up for it stil
l? Tb ok! XxX std chgs to send, £1.50 to rcv", 'Even my brother is not like
to speak with me. They treat me like aids patent.', "As per your request 'Me
lle Melle (Oru Minnaminunginte Nurungu Vettam)' has been set as your callert
une for all Callers. Press *9 to copy your friends Callertune", 'WINNER!! As
a valued network customer you have been selected to receivea £900 prize rewa
rd! To claim call 09061701461. Claim code KL341. Valid 12 hours only.', 'Had
your mobile 11 months or more? U R entitled to Update to the latest colour m
obiles with camera for Free! Call The Mobile Update Co FREE on 08002986030',
"I'm gonna be home soon and i don't want to talk about this stuff anymore to
night, k? I've cried enough today.", 'SIX chances to win CASH! From 100 to 2
0,000 pounds txt> CSH11 and send to 87575. Cost 150p/day, 6days, 16+ TsandCs
apply Reply HL 4 info', 'URGENT! You have won a 1 week FREE membership in ou
r £100,000 Prize Jackpot! Txt the word: CLAIM to No: 81010 T&C www.dbuk.net
LCCLTD POBOX 4403LDNW1A7RW18', "I've been searching for the right words to t
hank you for this breather. I promise i wont take your help for granted and
will fulfil my promise. You have been wonderful and a blessing at all time
s.", 'I HAVE A DATE ON SUNDAY WITH WILL!!', 'XXXMobileMovieClub: To use your
credit, click the WAP link in the next txt message or click here>> http://wa
p. (http://wap.) xxxmobilemovieclub.com?n=QJKGIGHJJGCBL', "Oh k...i'm watchi
ng here:)", 'Eh u remember how 2 spell his name... Yes i did. He v naughty m
ake until i v wet.', 'Fine if that\x92s the way u feel. That\x92s the way it
s gota b', 'England v Macedonia - dont miss the goals/team news. Txt ur nati
onal team to 87077 eg ENGLAND to 87077 Try:WALES, SCOTLAND 4txt/ú1.20 POBOXo
x36504W45WQ 16+', 'Is that seriously how you spell his name?', 'I‘m going to
try for 2 months ha ha only joking', 'So ü pay first lar... Then when is da
 stock comin...', 'Aft i finish my lunch then i go str down lor. Ard 3 smth
 lor. U finish ur lunch already?', 'Ffffffffff. Alright no way I can meet up
with you sooner?', "Just forced myself to eat a slice. I'm really not hungry
tho. This sucks. Mark is getting worried. He knows I'm sick when I turn down
pizza. Lol", 'Lol your always so convincing.', "Did you catch the bus ? Are
 you frying an egg ? Did you make a tea? Are you eating your mom's left over
dinner ? Do you feel my Love ?", "I'm back &amp;amp; we're packing the car now,
 I'll let you know if there's room", 'Ahhh. Work. I vaguely remember that! W
hat does it feel like? Lol', "Wait that's still not all that clear, were you
not sure about me being sarcastic or that that's why x doesn't want to live
 with us", "Yeah he got in at 2 and was v apologetic. n had fallen out and s
he was actin like spoilt child and he got caught up in that. Till 2! But we
 won't go there! Not doing too badly cheers. You? ", 'K tell me anything abo
ut you.', 'For fear of fainting with the of all that housework you just did?
Quick have a cuppa', 'Thanks for your subscription to Ringtone UK your mobil
e will be charged £5/month Please confirm by replying YES or NO. If you repl
y NO you will not be charged', 'Yup... Ok i go home look at the timings then
i msg ü again... Xuhui going to learn on 2nd may too but her lesson is at 8a
m', "Oops, I'll let you know when my roommate's done", 'I see the letter B o
n my car', 'Anything lor... U decide...', "Hello! How's you and how did satu
```

```
rday go? I was just texting to see if you'd decided to do anything tomo. Not
that i'm trying to invite myself or anything!", 'Pls go ahead with watts. I
 just wanted to be sure. Do have a great weekend. Abiola', 'Did I forget to
 tell you ? I want you , I need you, I crave you ... But most of all ... I l
ove you my sweet Arabian steed ... Mmmmmm ... Yummy', '07732584351 - Rodger
 Burns - MSG = We tried to call you re your reply to our sms for a free noki
a mobile + free camcorder. Please call now 08000930705 for delivery tomorro
w', 'WHO ARE YOU SEEING?', 'Great! I hope you like your man well endowed. I
 am  &lt;#&gt;  inches...', 'No calls..messages..missed calls', "Didn't you
 get hep b immunisation in nigeria.", 'Fair enough, anything going on?', "Ye
ah hopefully, if tyler can't do it I could maybe ask around a bit", "U don't
know how stubborn I am. I didn't even want to go to the hospital. I kept tel
ling Mark I'm not a weak sucker. Hospitals are for weak suckers."]
```

In [100]:

```
# preprocess messages using the preprocess function
messages = [preprocess(message) for message in messages]
print(messages)
```

```
['go jurong point , crazy.. available bugis n great world la e buffet ... ci
ne got amore wat ...', 'ok lar ... joking wif u oni ...', "free entry 2 wkly
comp win fa cup final tkts 21st may 2005. text fa 87121 receive entry questi
on ( std txt rate ) & c 's apply 08452810075over18 's", 'u dun say early hor
... u c already say ...', "nah n't think goes usf , lives around though", "f
reemsg hey darling 's 3 week 's word back ! 'd like fun still ? tb ok ! xxx
std chgs send , £1.50 rcv", 'even brother like speak . treat like aids paten
t .', "per request 'melle melle ( oru minnaminunginte nurungu vettam ) ' set
callertune callers . press *9 copy friends callertune", 'winner ! ! valued n
etwork customer selected receivea £900 prize reward ! claim call 0906170146
1. claim code kl341 . valid 12 hours .', 'mobile 11 months ? u r entitled up
date latest colour mobiles camera free ! call mobile update co free 08002986
030', "'m gon na home soon n't want talk stuff anymore tonight , k ? 've cri
ed enough today .", 'six chances win cash ! 100 20,000 pounds txt > csh11 se
nd 87575. cost 150p/day , 6days , 16+ tsandcs apply reply hl 4 info', 'urgen
t ! 1 week free membership £100,000 prize jackpot ! txt word : claim : 81010
& c www.dbuk.net lccltd pobox 4403ldnw1a7rw18', "'ve searching right words t
hank breather . promise wont take help granted fulfil promise . wonderful bl
essing times .", 'date sunday ! !', 'xxxmobilemovieclub : use credit , click
wap link next txt message click > > http : //wap . xxxmobilemovieclub.com ?
n=qjkgighjjgcbl', "oh k ... 'm watching : )", 'eh u remember 2 spell name
... yes . v naughty make v wet .', 'fine that\x92s way u feel . that\x92s wa
y gota b', 'england v macedonia - dont miss goals/team news . txt ur nationa
l team 87077 eg england 87077 try : wales , scotland 4txt/ú1.20 poboxox36504
w45wq 16+', 'seriously spell name ?', '‘ going try 2 months ha ha joking',
'ü pay first lar ... da stock comin ...', 'aft finish lunch go str lor . ard
3 smth lor . u finish ur lunch already ?', 'fffffffff . alright way meet so
oner ?', "forced eat slice . 'm really hungry tho . sucks . mark getting wor
ried . knows 'm sick turn pizza . lol", 'lol always convincing .', "catch bu
s ? frying egg ? make tea ? eating mom 's left dinner ? feel love ?", "'m ba
ck & amp ; 're packing car , 'll let know 's room", 'ahhh . work . vaguely r
emember ! feel like ? lol', "wait 's still clear , sure sarcastic 's x n't w
ant live us", "yeah got 2 v apologetic . n fallen actin like spoilt child go
t caught . till 2 ! wo n't go ! badly cheers . ?", 'k tell anything .', 'fea
r fainting housework ? quick cuppa', 'thanks subscription ringtone uk mobile
charged £5/month please confirm replying yes . reply charged', 'yup ... ok g
o home look timings msg ü ... xuhui going learn 2nd may lesson 8am', "oops ,
'll let know roommate 's done", 'see letter b car', 'anything lor ... u deci
de ...', "hello ! 's saturday go ? texting see 'd decided anything tomo . 'm
trying invite anything !", 'pls go ahead watts . wanted sure . great weekend
. abiola', 'forget tell ? want , need , crave ... ... love sweet arabian ste
ed ... mmmmmm ... yummy', '07732584351 - rodger burns - msg = tried call rep
ly sms free nokia mobile + free camcorder . please call 08000930705 delivery
tomorrow', 'seeing ?', 'great ! hope like man well endowed . & lt ; # & gt ;
inches ...', 'calls..messages..missed calls', "n't get hep b immunisation ni
geria .", 'fair enough , anything going ?', "yeah hopefully , tyler ca n't c
ould maybe ask around bit", "u n't know stubborn . n't even want go hospital
. kept telling mark 'm weak sucker . hospitals weak suckers ."]
```

In [101]:

```
# bag of words model
vectorizer = CountVectorizer()
bow_model = vectorizer.fit_transform(messages)
print(bow_model.toarray())
```

```
[[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]]
```

In [102]:

```
print(bow_model.shape)
print(vectorizer.get_feature_names())
```

```
(50, 381)
['000', '07732584351', '08000930705', '08002986030', '08452810075over18', '0
9061701461', '100', '11', '12', '150p', '16', '20', '2005', '21st', '2nd',
'4403ldnw1a7rw18', '4txt', '50', '6days', '81010', '87077', '87121', '8757
5', '8am', '900', 'abiola', 'actin', 'aft', 'ahead', 'ahhh', 'aids', 'alread
y', 'alright', 'always', 'amore', 'amp', 'anymore', 'anything', 'apologeti
c', 'apply', 'arabian', 'ard', 'around', 'ask', 'available', 'back', 'badl
y', 'bit', 'blessing', 'breather', 'brother', 'buffet', 'bugis', 'burns', 'b
us', 'ca', 'call', 'callers', 'callertune', 'calls', 'camcorder', 'camera',
'car', 'cash', 'catch', 'caught', 'chances', 'charged', 'cheers', 'chgs', 'c
hild', 'cine', 'claim', 'clear', 'click', 'co', 'code', 'colour', 'com', 'co
min', 'comp', 'confirm', 'convincing', 'copy', 'cost', 'could', 'crave', 'cr
azy', 'credit', 'cried', 'csh11', 'cup', 'cuppa', 'customer', 'da', 'darlin
g', 'date', 'day', 'dbuk', 'decide', 'decided', 'delivery', 'dinner', 'don
e', 'dont', 'dun', 'early', 'eat', 'eating', 'eg', 'egg', 'eh', 'endowed',
'england', 'enough', 'entitled', 'entry', 'even', 'fa', 'fainting', 'fair',
'fallen', 'fear', 'feel', 'ffffffffff', 'final', 'fine', 'finish', 'first',
'forced', 'forget', 'free', 'freemsg', 'friends', 'frying', 'fulfil', 'fun',
'get', 'getting', 'go', 'goals', 'goes', 'going', 'gon', 'got', 'gota', 'gra
nted', 'great', 'gt', 'ha', 'hello', 'help', 'hep', 'hey', 'hl', 'home', 'ho
pe', 'hopefully', 'hor', 'hospital', 'hospitals', 'hours', 'housework', 'htt
p', 'hungry', 'immunisation', 'inches', 'info', 'invite', 'jackpot', 'jokin
g', 'jurong', 'kept', 'kl341', 'know', 'knows', 'la', 'lar', 'latest', 'lccl
td', 'learn', 'left', 'lesson', 'let', 'letter', 'like', 'link', 'live', 'li
ves', 'll', 'lol', 'look', 'lor', 'love', 'lt', 'lunch', 'macedonia', 'mak
e', 'man', 'mark', 'may', 'maybe', 'meet', 'melle', 'membership', 'message',
'messages', 'minnaminunginte', 'miss', 'missed', 'mmmmmm', 'mobile', 'mobile
s', 'mom', 'month', 'months', 'msg', 'na', 'nah', 'name', 'national', 'naugh
ty', 'need', 'net', 'network', 'news', 'next', 'nigeria', 'nokia', 'nurung
u', 'oh', 'ok', 'oni', 'oops', 'oru', 'packing', 'patent', 'pay', 'per', 'pi
zza', 'please', 'pls', 'pobox', 'poboxox36504w45wq', 'point', 'pounds', 'pre
ss', 'prize', 'promise', 'qjkgighjjgcbl', 'question', 'quick', 'rate', 'rc
v', 're', 'really', 'receive', 'receivea', 'remember', 'reply', 'replying',
'request', 'reward', 'right', 'ringtone', 'rodger', 'room', 'roommate', 'sar
castic', 'saturday', 'say', 'scotland', 'searching', 'see', 'seeing', 'selec
ted', 'send', 'seriously', 'set', 'sick', 'six', 'slice', 'sms', 'smth', 'so
on', 'sooner', 'speak', 'spell', 'spoilt', 'std', 'steed', 'still', 'stock',
'str', 'stubborn', 'stuff', 'subscription', 'sucker', 'suckers', 'sucks', 's
unday', 'sure', 'sweet', 'take', 'talk', 'tb', 'tea', 'team', 'tell', 'telli
ng', 'text', 'texting', 'thank', 'thanks', 'that', 'think', 'tho', 'though',
'till', 'times', 'timings', 'tkts', 'today', 'tomo', 'tomorrow', 'tonight',
'treat', 'tried', 'try', 'trying', 'tsandcs', 'turn', 'txt', 'tyler', 'uk',
'update', 'ur', 'urgent', 'us', 'use', 'usf', 'vaguely', 'valid', 'valued',
've', 'vettam', 'wait', 'wales', 'want', 'wanted', 'wap', 'wat', 'watching',
'watts', 'way', 'weak', 'week', 'weekend', 'well', 'wet', 'wif', 'win', 'win
ner', 'wkly', 'wo', 'wonderful', 'wont', 'word', 'words', 'work', 'world',
'worried', 'www', 'xuhui', 'xxx', 'xxxmobilemovieclub', 'yeah', 'yes', 'yumm
y', 'yup', 'ú1']
```

- A lot of duplicate tokens such as 'win'and 'winner'; 'reply' and 'replying'; 'want' and 'wanted' etc.

Stemming and lemmatising

In [103]:

```
from nltk.stem.porter import PorterStemmer
from nltk.stem import WordNetLemmatizer


stemmer = PorterStemmer()
wordnet_lemmatizer = WordNetLemmatizer()

# add stemming and lemmatisation in the preprocess function
def preprocess(document, stem=True):
    'changes document to lower case and removes stopwords'

    # change sentence to lower case
    document = document.lower()

    # tokenize into words
    words = word_tokenize(document)

    # remove stop words
    words = [word for word in words if word not in stopwords.words("english")]

    if stem:
        words = [stemmer.stem(word) for word in words]
    else:
        words = [wordnet_lemmatizer.lemmatize(word, pos='v') for word in words]

    # join words to make sentence
    document = " ".join(words)

    return document
```

Bag of words model on stemmed messages

In [104]:

```
# stem messages
messages = [preprocess(message, stem=True) for message in spam.message]

# bag of words model
vectorizer = CountVectorizer()
bow_model = vectorizer.fit_transform(messages)
```

In [105]:

```
# Look at the dataframe
pd.DataFrame(bow_model.toarray(), columns = vectorizer.get_feature_names())
```

Out[105]:

	000	07732584351	08000930705	08002986030	08452810075over18	09061701461	100	11	1
0	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	
2	0	0	0	0	1	0	0	0	
3	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	1	0	0	
9	0	0	0	1	0	0	0	1	
10	0	0	0	0	0	0	0	0	
11	1	0	0	0	0	0	1	0	
12	1	0	0	0	0	0	1	0	
13	0	0	0	0	0	0	0	0	
14	0	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	0	
16	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	0	
30	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0	0	

	000	07732584351	08000930705	08002986030	08452810075over18	09061701461	100	11	1
32	0	0	0	0	0	0	0	0	
33	0	0	0	0	0	0	0	0	
34	0	0	0	0	0	0	0	0	
35	0	0	0	0	0	0	0	0	
36	0	0	0	0	0	0	0	0	
37	0	0	0	0	0	0	0	0	
38	0	0	0	0	0	0	0	0	
39	0	0	0	0	0	0	0	0	
40	0	0	0	0	0	0	0	0	
41	0	0	0	0	0	0	0	0	
42	0	1	1	0	0	0	0	0	
43	0	0	0	0	0	0	0	0	
44	0	0	0	0	0	0	0	0	
45	0	0	0	0	0	0	0	0	
46	0	0	0	0	0	0	0	0	
47	0	0	0	0	0	0	0	0	
48	0	0	0	0	0	0	0	0	
49	0	0	0	0	0	0	0	0	

50 rows × 359 columns

In [107]:

```
# token names
print(vectorizer.get_feature_names())
```

```
['000', '07732584351', '08000930705', '08002986030', '08452810075over18', '0
9061701461', '100', '11', '12', '150p', '16', '20', '2005', '21st', '2nd',
'4403ldnw1a7rw18', '4txt', '50', '6day', '81010', '87077', '87121', '87575',
'8am', '900', 'abiola', 'actin', 'aft', 'ahead', 'ahhh', 'aid', 'alreadi',
'alright', 'alway', 'amor', 'amp', 'anymor', 'anyth', 'apologet', 'appli',
'arabian', 'ard', 'around', 'ask', 'avail', 'back', 'badli', 'bit', 'bless',
'breather', 'brother', 'bu', 'buffet', 'bugi', 'burn', 'ca', 'call', 'calle
r', 'callertun', 'calls', 'camcord', 'camera', 'car', 'cash', 'catch', 'caug
ht', 'chanc', 'charg', 'cheer', 'chg', 'child', 'cine', 'claim', 'clear', 'c
lick', 'co', 'code', 'colour', 'com', 'comin', 'comp', 'confirm', 'convinc',
'copi', 'cost', 'could', 'crave', 'crazy', 'credit', 'cri', 'csh11', 'cup',
'cuppa', 'custom', 'da', 'darl', 'date', 'day', 'dbuk', 'decid', 'deliveri',
'dinner', 'done', 'dont', 'dun', 'earli', 'eat', 'eg', 'egg', 'eh', 'endow',
'england', 'enough', 'entitl', 'entri', 'even', 'fa', 'faint', 'fair', 'fall
en', 'fear', 'feel', 'ffffffffff', 'final', 'fine', 'finish', 'first', 'for
c', 'forget', 'free', 'freemsg', 'fri', 'friend', 'fulfil', 'fun', 'get', 'g
o', 'goals', 'goe', 'gon', 'got', 'gota', 'grant', 'great', 'gt', 'ha', 'hel
lo', 'help', 'hep', 'hey', 'hl', 'home', 'hope', 'hor', 'hospit', 'hour', 'h
ousework', 'http', 'hungri', 'immunis', 'inch', 'info', 'invit', 'jackpot',
'joke', 'jurong', 'kept', 'kl341', 'know', 'la', 'lar', 'latest', 'lccltd',
'learn', 'left', 'lesson', 'let', 'letter', 'like', 'link', 'live', 'll', 'l
ol', 'look', 'lor', 'love', 'lt', 'lunch', 'macedonia', 'make', 'man', 'mar
k', 'may', 'mayb', 'meet', 'mell', 'membership', 'messag', 'messages', 'minn
aminungint', 'miss', 'mmmmmm', 'mobil', 'mom', 'month', 'msg', 'na', 'nah',
'name', 'nation', 'naughti', 'need', 'net', 'network', 'news', 'next', 'nige
ria', 'nokia', 'nurungu', 'oh', 'ok', 'oni', 'oop', 'oru', 'pack', 'patent',
'pay', 'per', 'pizza', 'pl', 'pleas', 'pobox', 'poboxox36504w45wq', 'point',
'pound', 'press', 'prize', 'promis', 'qjkgighjjgcbl', 'question', 'quick',
'rate', 'rcv', 're', 'realli', 'receiv', 'receivea', 'rememb', 'repli', 'req
uest', 'reward', 'right', 'rington', 'rodger', 'room', 'roommat', 'sarcast',
'saturday', 'say', 'scotland', 'search', 'see', 'select', 'send', 'serious',
'set', 'sick', 'six', 'slice', 'sm', 'smth', 'soon', 'sooner', 'speak', 'spe
ll', 'spoilt', 'std', 'steed', 'still', 'stock', 'str', 'stubborn', 'stuff',
'subscript', 'suck', 'sucker', 'sunday', 'sure', 'sweet', 'take', 'talk', 't
b', 'tea', 'team', 'tell', 'text', 'thank', 'that', 'think', 'tho', 'thoug
h', 'till', 'time', 'tkt', 'today', 'tomo', 'tomorrow', 'tonight', 'treat',
'tri', 'tsandc', 'turn', 'txt', 'tyler', 'uk', 'updat', 'ur', 'urgent', 'u
s', 'use', 'usf', 'vagu', 'valid', 'valu', 've', 'vettam', 'wait', 'wale',
'want', 'wap', 'wat', 'watch', 'watt', 'way', 'weak', 'week', 'weekend', 'we
ll', 'wet', 'wif', 'win', 'winner', 'wkli', 'wo', 'wonder', 'wont', 'word',
'work', 'world', 'worri', 'www', 'xuhui', 'xxx', 'xxxmobilemovieclub', 'ye',
'yeah', 'yummi', 'yup', 'ú1']
```

359 tokens after lemmatizing the messages as compared to 381 tokens without stemming.

Let's try lemmatizing the messages.

In [108]:

```
# lemmatise messages
messages = [preprocess(message, stem=False) for message in spam.message]

# bag of words model
vectorizer = CountVectorizer()
bow_model = vectorizer.fit_transform(messages)
```

In [109]:

```
# Look at the dataframe
pd.DataFrame(bow_model.toarray(), columns = vectorizer.get_feature_names())
```

Out[109]:

	000	07732584351	08000930705	08002986030	08452810075over18	09061701461	100	11	1
0	0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	0	
2	0	0	0	0	1	0	0	0	
3	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	1	0	0	
9	0	0	0	1	0	0	0	1	
10	0	0	0	0	0	0	0	0	
11	1	0	0	0	0	0	1	0	
12	1	0	0	0	0	0	1	0	
13	0	0	0	0	0	0	0	0	
14	0	0	0	0	0	0	0	0	
15	0	0	0	0	0	0	0	0	
16	0	0	0	0	0	0	0	0	
17	0	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0	
19	0	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	0	
21	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	
25	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	0	
30	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0	0	

	000	07732584351	08000930705	08002986030	08452810075over18	09061701461	100	11	1
32	0	0	0	0	0	0	0	0	
33	0	0	0	0	0	0	0	0	
34	0	0	0	0	0	0	0	0	
35	0	0	0	0	0	0	0	0	
36	0	0	0	0	0	0	0	0	
37	0	0	0	0	0	0	0	0	
38	0	0	0	0	0	0	0	0	
39	0	0	0	0	0	0	0	0	
40	0	0	0	0	0	0	0	0	
41	0	0	0	0	0	0	0	0	
42	0	1	1	0	0	0	0	0	
43	0	0	0	0	0	0	0	0	
44	0	0	0	0	0	0	0	0	
45	0	0	0	0	0	0	0	0	
46	0	0	0	0	0	0	0	0	
47	0	0	0	0	0	0	0	0	
48	0	0	0	0	0	0	0	0	
49	0	0	0	0	0	0	0	0	

50 rows × 363 columns

In [110]:

```
# token names
print(vectorizer.get_feature_names())
```

```
['000', '07732584351', '08000930705', '08002986030', '08452810075over18', '0
9061701461', '100', '11', '12', '150p', '16', '20', '2005', '21st', '2nd',
'4403ldnw1a7rw18', '4txt', '50', '6days', '81010', '87077', '87121', '8757
5', '8am', '900', 'abiola', 'actin', 'aft', 'ahead', 'ahhh', 'aid', 'alread
y', 'alright', 'always', 'amore', 'amp', 'anymore', 'anything', 'apologeti
c', 'apply', 'arabian', 'ard', 'around', 'ask', 'available', 'back', 'badl
y', 'bite', 'bless', 'breather', 'brother', 'buffet', 'bugis', 'burn', 'bu
s', 'ca', 'call', 'callers', 'callertune', 'calls', 'camcorder', 'camera',
'car', 'cash', 'catch', 'chance', 'charge', 'cheer', 'chgs', 'child', 'cin
e', 'claim', 'clear', 'click', 'co', 'code', 'colour', 'com', 'comin', 'com
p', 'confirm', 'convince', 'copy', 'cost', 'could', 'crave', 'crazy', 'credi
t', 'cry', 'csh11', 'cup', 'cuppa', 'customer', 'da', 'darling', 'date', 'da
y', 'dbuk', 'decide', 'delivery', 'dinner', 'do', 'dont', 'dun', 'early', 'e
at', 'eg', 'egg', 'eh', 'endow', 'england', 'enough', 'entitle', 'entry', 'e
ven', 'fa', 'faint', 'fair', 'fall', 'fear', 'feel', 'fffffffff', 'final',
'fine', 'finish', 'first', 'force', 'forget', 'free', 'freemsg', 'friends',
'fry', 'fulfil', 'fun', 'get', 'go', 'goals', 'gon', 'gota', 'grant', 'grea
t', 'gt', 'ha', 'hello', 'help', 'hep', 'hey', 'hl', 'home', 'hope', 'hopefu
lly', 'hor', 'hospital', 'hospitals', 'hours', 'housework', 'http', 'hungr
y', 'immunisation', 'inch', 'info', 'invite', 'jackpot', 'joke', 'jurong',
'keep', 'kl341', 'know', 'la', 'lar', 'latest', 'lccltd', 'learn', 'leave',
'lesson', 'let', 'letter', 'like', 'link', 'live', 'll', 'lol', 'look', 'lo
r', 'love', 'lt', 'lunch', 'macedonia', 'make', 'man', 'mark', 'may', 'mayb
e', 'meet', 'melle', 'membership', 'message', 'messages', 'minnaminunginte',
'miss', 'missed', 'mmmmmm', 'mobile', 'mobiles', 'mom', 'month', 'months',
'msg', 'na', 'nah', 'name', 'national', 'naughty', 'need', 'net', 'network',
'news', 'next', 'nigeria', 'nokia', 'nurungu', 'oh', 'ok', 'oni', 'oops', 'o
ru', 'pack', 'patent', 'pay', 'per', 'pizza', 'please', 'pls', 'pobox', 'pob
oxox36504w45wq', 'point', 'pound', 'press', 'prize', 'promise', 'qjkgighjjgc
bl', 'question', 'quick', 'rate', 'rcv', 're', 'really', 'receive', 'receive
a', 'remember', 'reply', 'request', 'reward', 'right', 'ringtone', 'rodger',
'room', 'roommate', 'sarcastic', 'saturday', 'say', 'scotland', 'search', 's
ee', 'select', 'send', 'seriously', 'set', 'sick', 'six', 'slice', 'sms', 's
mth', 'soon', 'sooner', 'speak', 'spell', 'spoil', 'std', 'steed', 'still',
'stock', 'str', 'stubborn', 'stuff', 'subscription', 'suck', 'sucker', 'suck
ers', 'sunday', 'sure', 'sweet', 'take', 'talk', 'tb', 'tea', 'team', 'tel
l', 'text', 'texting', 'thank', 'that', 'think', 'tho', 'though', 'till', 't
ime', 'tkts', 'today', 'tomo', 'tomorrow', 'tonight', 'treat', 'try', 'tsand
cs', 'turn', 'txt', 'tyler', 'uk', 'update', 'ur', 'urgent', 'us', 'use', 'u
sf', 'vaguely', 'valid', 'value', 've', 'vettam', 'wait', 'wales', 'want',
'wap', 'wat', 'watch', 'watts', 'way', 'weak', 'week', 'weekend', 'well', 'w
et', 'wif', 'win', 'winner', 'wkly', 'wo', 'wonderful', 'wont', 'word', 'wor
k', 'world', 'worry', 'www', 'xuhui', 'xxx', 'xxxmobilemovieclub', 'yeah',
'yes', 'yummy', 'yup', 'ú1']
```

363 tokens after lemmatizing the messages as compared to 381 tokens without lemmatising. But, on the other hand, stemmer reduces the token count to 359. Lemmatization doesn't work as expected because the data is very unclean.

TF-IDF Representation

The bag of words representation, while effective, is a very naive way of representing text. It relies on just the word frequencies of the words of a document. But don't you think word representation shouldn't solely rely on the word frequency? There is another way to represent documents in a matrix format which represents a word in a smarter way. It's called the TF-IDF representation and it is the one that is often preferred by most data scientists.

The term TF stands for term frequency, and the term IDF stands for inverse document frequency. How is this different from bag-of-words representation? Professor Srinath explains the concept of TF-IDF below.TF-IDF Representation The bag of words representation, while effective, is a very naive way of representing text. It relies on just the word frequencies of the words of a document. But don't you think word representation shouldn't solely rely on the word frequency? There is another way to represent documents in a matrix format which represents a word in a smarter way. It's called the TF-IDF representation and it is the one that is often preferred by most data scientists.

The term TF stands for term frequency, and the term IDF stands for inverse document frequency. How is this different from bag-of-words representation? Professor Srinath explains the concept of TF-IDF below.

TF-IDF MODEL

Document 1 : "Gangs of Wasseypur is a great movie. Wasseypur is a town in Bihar."
Document 2 : "The success of a song depends on the music."
Document 3 : "There is a new movie releasing this week. The movie is fun to watch."

	bihar	depends	fun	gangs	great	movie	music	new	releasing	song	success	town	wasseypur	watch	week
1						0.025									
2															
3						0.05									

$$tf_{t,d} = \frac{f_{t,d}}{\sum_t f_{t,d}} \qquad tf_{movie,d1} = \frac{1}{7} \qquad idf_t = \log \frac{|D|}{|D_t|} \qquad idf_{movie} = \log \frac{3}{2}$$

$$\text{tf-idf}_{movie} = \frac{1}{7} \times \log \frac{3}{2} = 0.025$$

The TF-IDF representation, also called the TF-IDF model, takes into the account the importance of each word. In the bag-of-words model, each word is assumed to be equally important, which is of course not correct.

The formula to calculate TF-IDF weight of a term in a document is:

$$tf_{t,d} = \frac{frequency\ of\ term\ 't'\ in\ document\ 'd'}{total\ terms\ in\ document\ 'd'}$$

$$idf_t = log \frac{total\ number\ of\ documents}{total\ documents\ that\ have\ the\ term\ 't'}$$

The log in the above formula is with base 10. Now, the tf-idf score for any term in a document is just the product of these two terms:

$$tf - idf = tf_{t,d} * idf_t$$

Higher weights are assigned to terms that are present frequently in a document and which are rare among all documents. On the other hand, a low score is assigned to terms which are common across all documents.

Now, attempt the following quiz. Questions 1-3 are based on the following set of documents: Document1: "Vapour, Bangalore has a really great terrace seating and an awesome view of the Bangalore skyline" Document2: "The beer at Vapour, Bangalore was amazing. My favourites are the wheat beer and the ale beer." Document3: "Vapour, Bangalore has the best view in Bangalore."

What is the tf-idf score of the term ‘Bangalore’ in document one? (Remove stop words and punctuations before calculating the tf-idf score).

Solution : TF('Bangalore', document1) is 0.2 since there are a total of 10 terms and Bangalore occurs two times. The idf('Bangalore') is log10(3/3) which equals zero. Tf-idf is tf*idf which will be equal to zero.

Note that tf-idf is implemented in different ways in different languages and packages. In the tf score representation, some people use only the frequency of the term, i.e. they don’t divide the frequency of the term with the total number of terms. In the idf score representation, some people use natural log instead of the log with base 10. Due to this, you may see a different score of the same terms in the same set of documents. But the goal remains the same - assign a weight according to the word's importance.

TF-IDF model

In [111]:

```
# load all necessary libraries
import pandas as pd
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
from sklearn.feature_extraction.text import TfidfVectorizer

pd.set_option('max_colwidth', 100)
```

Let's build a basic bag of words model on three sample documents

In [112]:

```
documents = ["Gangs of Wasseypur is a great movie. Wasseypur is a town in Bihar.", "The suc
print(documents)
```

```
['Gangs of Wasseypur is a great movie. Wasseypur is a town in Bihar.', 'The
success of a song depends on the music.', 'There is a new movie releasing th
is week. The movie is fun to watch.']
```

In [113]:

```
documents = ["Vapour, Bangalore has a really great terrace seating and an awesome view of t
             "The beer at Vapour, Bangalore was amazing. My favorites are the wheat beer an
             "Vapour, Bangalore has the best view in Bangalore."]
print(documents)
```

```
['Vapour, Bangalore has a really great terrace seating and an awesome view o
f the Bangalore skyline', 'The beer at Vapour, Bangalore was amazing. My fav
orites are the wheat beer and the ale beer.', 'Vapour, Bangalore has the bes
t view in Bangalore.']
```

In [114]:

```
from nltk.stem.porter import PorterStemmer

stemmer = PorterStemmer()

# add stemming and lemmatisation in the preprocess function
def preprocess(document):
    'changes document to lower case and removes stopwords'

    # change sentence to lower case
    document = document.lower()

    # tokenize into words
    words = word_tokenize(document)

    # remove stop words
    words = [word for word in words if word not in stopwords.words("english")]

    # stem
    #words = [stemmer.stem(word) for word in words]

    # join words to make sentence
    document = " ".join(words)

    return document
```

In [115]:

```
documents = [preprocess(document) for document in documents]
print(documents)
```

```
['vapour , bangalore really great terrace seating awesome view bangalore sky
line', 'beer vapour , bangalore amazing . favorites wheat beer ale beer .',
'vapour , bangalore best view bangalore .']
```

Creating bag of words model using count vectorizer function

In [116]:

```
vectorizer = TfidfVectorizer()
tfidf_model = vectorizer.fit_transform(documents)
print(tfidf_model)  # returns the row number and column number of cells which have 1 as val
```

```
  (0, 12)       0.20472809091871683
  (0, 3)        0.40945618183743365
  (0, 8)        0.34663478992044555
  (0, 7)        0.34663478992044555
  (0, 11)       0.34663478992044555
  (0, 9)        0.34663478992044555
  (0, 2)        0.34663478992044555
  (0, 13)       0.2636246924033099
  (0, 10)       0.34663478992044555
  (1, 12)       0.15958136664279546
  (1, 3)        0.15958136664279546
  (1, 4)        0.8105842230034561
  (1, 1)        0.27019474100115204
  (1, 6)        0.27019474100115204
  (1, 14)       0.27019474100115204
  (1, 0)        0.27019474100115204
  (2, 12)       0.32401895323148033
  (2, 3)        0.6480379064629607
  (2, 13)       0.41723339721076924
  (2, 5)        0.5486117771118657
```

In [117]:

```
# print the full sparse matrix
print(tfidf_model.toarray())
```

```
[[0.         0.         0.34663479 0.40945618 0.         0.
  0.         0.34663479 0.34663479 0.34663479 0.34663479 0.34663479
  0.20472809 0.26362469 0.        ]
 [0.27019474 0.27019474 0.         0.15958137 0.81058422 0.
  0.27019474 0.         0.         0.         0.         0.
  0.15958137 0.         0.27019474]
 [0.         0.         0.         0.64803791 0.         0.54861178
  0.         0.         0.         0.         0.         0.
  0.32401895 0.4172334  0.        ]]
```

In [118]:

```
pd.DataFrame(tfidf_model.toarray(), columns = vectorizer.get_feature_names())
```

Out[118]:

	ale	amazing	awesome	bangalore	beer	best	favorites	great	really
0	0.000000	0.000000	0.346635	0.409456	0.000000	0.000000	0.000000	0.346635	0.346635
1	0.270195	0.270195	0.000000	0.159581	0.810584	0.000000	0.270195	0.000000	0.000000
2	0.000000	0.000000	0.000000	0.648038	0.000000	0.548612	0.000000	0.000000	0.000000

Let's create a tf-idf model on the spam dataset.

In [120]:

```
# Load data
spam = pd.read_csv("SMSSpamCollection_tfidf.txt", sep = "\t", names=["label", "message"])
spam.head()
```

Out[120]:

	label	message
0	ham	Go until jurong point, crazy.. Available only in bugis n great world la e buffet... Cine there g...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Text FA to 87121 to receive ...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives around here though

Let's take a subset of data (first 50 rows only) and create bag of word model on that.

In [121]:

```
spam = spam.iloc[0:50,:]
print(spam)
```

```
25    ham
26    ham
27    ham
28    ham
29    ham
30    ham
31    ham
32    ham
33    ham
34   spam
35    ham
36    ham
37    ham
38    ham
39    ham
40    ham
41    ham
42   spam
43    ham
44    ham
```

In [122]:

```
# extract the messages from the dataframe
messages = [message for message in spam.message]
print(messages)
```

```
['Go until jurong point, crazy.. Available only in bugis n great world la e
buffet... Cine there got amore wat...', 'Ok lar... Joking wif u oni...', "Fr
ee entry in 2 a wkly comp to win FA Cup final tkts 21st May 2005. Text FA to
87121 to receive entry question(std txt rate)T&C's apply 08452810075over1
8's", 'U dun say so early hor... U c already then say...', "Nah I don't thin
k he goes to usf, he lives around here though", "FreeMsg Hey there darling i
t's been 3 week's now and no word back! I'd like some fun you up for it stil
l? Tb ok! XxX std chgs to send, £1.50 to rcv", 'Even my brother is not like
to speak with me. They treat me like aids patent.', "As per your request 'Me
lle Melle (Oru Minnaminunginte Nurungu Vettam)' has been set as your callert
une for all Callers. Press *9 to copy your friends Callertune", 'WINNER!! As
a valued network customer you have been selected to receivea £900 prize rewa
rd! To claim call 09061701461. Claim code KL341. Valid 12 hours only.', 'Had
your mobile 11 months or more? U R entitled to Update to the latest colour m
obiles with camera for Free! Call The Mobile Update Co FREE on 08002986030',
"I'm gonna be home soon and i don't want to talk about this stuff anymore to
night, k? I've cried enough today.", 'SIX chances to win CASH! From 100 to 2
0,000 pounds txt> CSH11 and send to 87575. Cost 150p/day, 6days, 16+ TsandCs
apply Reply HL 4 info', 'URGENT! You have won a 1 week FREE membership in ou
r £100,000 Prize Jackpot! Txt the word: CLAIM to No: 81010 T&C www.dbuk.net
LCCLTD POBOX 4403LDNW1A7RW18', "I've been searching for the right words to t
hank you for this breather. I promise i wont take your help for granted and
will fulfil my promise. You have been wonderful and a blessing at all time
s.", 'I HAVE A DATE ON SUNDAY WITH WILL!!', 'XXXMobileMovieClub: To use your
credit, click the WAP link in the next txt message or click here>> http://wa
p. (http://wap.) xxxmobilemovieclub.com?n=QJKGIGHJJGCBL', "Oh k...i'm watchi
ng here:)", 'Eh u remember how 2 spell his name... Yes i did. He v naughty m
ake until i v wet.', 'Fine if that\x92s the way u feel. That\x92s the way it
s gota b', 'England v Macedonia - dont miss the goals/team news. Txt ur nati
onal team to 87077 eg ENGLAND to 87077 Try:WALES, SCOTLAND 4txt/ú1.20 POBOXo
x36504W45WQ 16+', 'Is that seriously how you spell his name?', 'I‘m going to
try for 2 months ha ha only joking', 'So ü pay first lar... Then when is da
 stock comin...', 'Aft i finish my lunch then i go str down lor. Ard 3 smth
 lor. U finish ur lunch already?', 'Ffffffffff. Alright no way I can meet up
with you sooner?', "Just forced myself to eat a slice. I'm really not hungry
tho. This sucks. Mark is getting worried. He knows I'm sick when I turn down
pizza. Lol", 'Lol your always so convincing.', "Did you catch the bus ? Are
 you frying an egg ? Did you make a tea? Are you eating your mom's left over
dinner ? Do you feel my Love ?", "I'm back &amp;amp; we're packing the car now,
 I'll let you know if there's room", 'Ahhh. Work. I vaguely remember that! W
hat does it feel like? Lol', "Wait that's still not all that clear, were you
not sure about me being sarcastic or that that's why x doesn't want to live
 with us", "Yeah he got in at 2 and was v apologetic. n had fallen out and s
he was actin like spoilt child and he got caught up in that. Till 2! But we
 won't go there! Not doing too badly cheers. You? ", 'K tell me anything abo
ut you.', 'For fear of fainting with the of all that housework you just did?
Quick have a cuppa', 'Thanks for your subscription to Ringtone UK your mobil
e will be charged £5/month Please confirm by replying YES or NO. If you repl
y NO you will not be charged', 'Yup... Ok i go home look at the timings then
i msg ü again... Xuhui going to learn on 2nd may too but her lesson is at 8a
m', "Oops, I'll let you know when my roommate's done", 'I see the letter B o
n my car', 'Anything lor... U decide...', "Hello! How's you and how did satu
```

```
rday go? I was just texting to see if you'd decided to do anything tomo. Not
that i'm trying to invite myself or anything!", 'Pls go ahead with watts. I
 just wanted to be sure. Do have a great weekend. Abiola', 'Did I forget to
 tell you ? I want you , I need you, I crave you ... But most of all ... I l
ove you my sweet Arabian steed ... Mmmmmm ... Yummy', '07732584351 - Rodger
 Burns - MSG = We tried to call you re your reply to our sms for a free noki
a mobile + free camcorder. Please call now 08000930705 for delivery tomorro
w', 'WHO ARE YOU SEEING?', 'Great! I hope you like your man well endowed. I
 am  &lt;#&gt;  inches...', 'No calls..messages..missed calls', "Didn't you
 get hep b immunisation in nigeria.", 'Fair enough, anything going on?', "Ye
ah hopefully, if tyler can't do it I could maybe ask around a bit", "U don't
know how stubborn I am. I didn't even want to go to the hospital. I kept tel
ling Mark I'm not a weak sucker. Hospitals are for weak suckers."]
```

In [123]:

```
# preprocess messages using the preprocess function
messages = [preprocess(message) for message in messages]
print(messages)
```

```
['go jurong point , crazy.. available bugis n great world la e buffet ...
cine got amore wat ...', 'ok lar ... joking wif u oni ...', "free entry 2
wkly comp win fa cup final tkts 21st may 2005. text fa 87121 receive entr
y question ( std txt rate ) & c 's apply 08452810075over18 's", 'u dun sa
y early hor ... u c already say ...', "nah n't think goes usf , lives aro
und though", "freemsg hey darling 's 3 week 's word back ! 'd like fun st
ill ? tb ok ! xxx std chgs send , £1.50 rcv", 'even brother like speak .
treat like aids patent .', "per request 'melle melle ( oru minnaminungint
e nurungu vettam ) ' set callertune callers . press *9 copy friends calle
rtune", 'winner ! ! valued network customer selected receivea £900 prize
reward ! claim call 09061701461. claim code kl341 . valid 12 hours .', 'm
obile 11 months ? u r entitled update latest colour mobiles camera free !
call mobile update co free 08002986030', "'m gon na home soon n't want ta
lk stuff anymore tonight , k ? 've cried enough today .", 'six chances wi
n cash ! 100 20,000 pounds txt > csh11 send 87575. cost 150p/day , 6days
, 16+ tsandcs apply reply hl 4 info', 'urgent ! 1 week free membership £1
00,000 prize jackpot ! txt word : claim : 81010 & c www.dbuk.net lccltd p
obox 4403ldnw1a7rw18', "'ve searching right words thank breather . promis
e wont take help granted fulfil promise . wonderful blessing times .", 'd
```

In [124]:

```
# bag of words model
vectorizer = TfidfVectorizer()
tfidf_model = vectorizer.fit_transform(messages)
```

In [125]:

```
# Let's look at the dataframe
tfidf = pd.DataFrame(tfidf_model.toarray(), columns = vectorizer.get_feature_names())
tfidf
```

Out[125]:

	000	07732584351	08000930705	08002986030	08452810075over18	09061701461	
0	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
1	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
2	0.000000	0.000000	0.000000	0.000000	0.198284	0.000000	0.000(
3	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
4	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
5	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
6	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
7	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
8	0.000000	0.000000	0.000000	0.000000	0.000000	0.230701	0.000(
9	0.000000	0.000000	0.000000	0.230794	0.000000	0.000000	0.000(
10	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
11	0.202352	0.000000	0.000000	0.000000	0.000000	0.000000	0.202:
12	0.225591	0.000000	0.000000	0.000000	0.000000	0.000000	0.225:
13	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
14	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
15	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
16	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
17	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
18	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
19	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
20	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
21	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
22	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
23	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
24	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
25	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
26	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
27	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
28	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
29	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(
30	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000(

	000	07732584351	08000930705	08002986030	08452810075over18	09061701461	
31	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
32	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
33	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
34	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
35	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
36	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
37	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
38	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
39	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
40	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
41	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
42	0.000000	0.233818	0.233818	0.000000	0.000000	0.000000	0.0000
43	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
44	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
45	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
46	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
47	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
48	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
49	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000

50 rows × 381 columns

In [126]:

```
# token names
print(vectorizer.get_feature_names())
```

```
['000', '07732584351', '08000930705', '08002986030', '08452810075over18', '0
9061701461', '100', '11', '12', '150p', '16', '20', '2005', '21st', '2nd',
'4403ldnw1a7rw18', '4txt', '50', '6days', '81010', '87077', '87121', '8757
5', '8am', '900', 'abiola', 'actin', 'aft', 'ahead', 'ahhh', 'aids', 'alread
y', 'alright', 'always', 'amore', 'amp', 'anymore', 'anything', 'apologeti
c', 'apply', 'arabian', 'ard', 'around', 'ask', 'available', 'back', 'badl
y', 'bit', 'blessing', 'breather', 'brother', 'buffet', 'bugis', 'burns', 'b
us', 'ca', 'call', 'callers', 'callertune', 'calls', 'camcorder', 'camera',
'car', 'cash', 'catch', 'caught', 'chances', 'charged', 'cheers', 'chgs', 'c
hild', 'cine', 'claim', 'clear', 'click', 'co', 'code', 'colour', 'com', 'co
min', 'comp', 'confirm', 'convincing', 'copy', 'cost', 'could', 'crave', 'cr
azy', 'credit', 'cried', 'csh11', 'cup', 'cuppa', 'customer', 'da', 'darlin
g', 'date', 'day', 'dbuk', 'decide', 'decided', 'delivery', 'dinner', 'don
e', 'dont', 'dun', 'early', 'eat', 'eating', 'eg', 'egg', 'eh', 'endowed',
'england', 'enough', 'entitled', 'entry', 'even', 'fa', 'fainting', 'fair',
'fallen', 'fear', 'feel', 'ffffffffff', 'final', 'fine', 'finish', 'first',
'forced', 'forget', 'free', 'freemsg', 'friends', 'frying', 'fulfil', 'fun',
'get', 'getting', 'go', 'goals', 'goes', 'going', 'gon', 'got', 'gota', 'gra
nted', 'great', 'gt', 'ha', 'hello', 'help', 'hep', 'hey', 'hl', 'home', 'ho
pe', 'hopefully', 'hor', 'hospital', 'hospitals', 'hours', 'housework', 'htt
p', 'hungry', 'immunisation', 'inches', 'info', 'invite', 'jackpot', 'jokin
g', 'jurong', 'kept', 'kl341', 'know', 'knows', 'la', 'lar', 'latest', 'lccl
td', 'learn', 'left', 'lesson', 'let', 'letter', 'like', 'link', 'live', 'li
ves', 'll', 'lol', 'look', 'lor', 'love', 'lt', 'lunch', 'macedonia', 'mak
e', 'man', 'mark', 'may', 'maybe', 'meet', 'melle', 'membership', 'message',
'messages', 'minnaminunginte', 'miss', 'missed', 'mmmmmm', 'mobile', 'mobile
s', 'mom', 'month', 'months', 'msg', 'na', 'nah', 'name', 'national', 'naugh
ty', 'need', 'net', 'network', 'news', 'next', 'nigeria', 'nokia', 'nurung
u', 'oh', 'ok', 'oni', 'oops', 'oru', 'packing', 'patent', 'pay', 'per', 'pi
zza', 'please', 'pls', 'pobox', 'poboxox36504w45wq', 'point', 'pounds', 'pre
ss', 'prize', 'promise', 'qjkgighjjgcbl', 'question', 'quick', 'rate', 'rc
v', 're', 'really', 'receive', 'receivea', 'remember', 'reply', 'replying',
'request', 'reward', 'right', 'ringtone', 'rodger', 'room', 'roommate', 'sar
castic', 'saturday', 'say', 'scotland', 'searching', 'see', 'seeing', 'selec
ted', 'send', 'seriously', 'set', 'sick', 'six', 'slice', 'sms', 'smth', 'so
on', 'sooner', 'speak', 'spell', 'spoilt', 'std', 'steed', 'still', 'stock',
'str', 'stubborn', 'stuff', 'subscription', 'sucker', 'suckers', 'sucks', 's
unday', 'sure', 'sweet', 'take', 'talk', 'tb', 'tea', 'team', 'tell', 'telli
ng', 'text', 'texting', 'thank', 'thanks', 'that', 'think', 'tho', 'though',
'till', 'times', 'timings', 'tkts', 'today', 'tomo', 'tomorrow', 'tonight',
'treat', 'tried', 'try', 'trying', 'tsandcs', 'turn', 'txt', 'tyler', 'uk',
'update', 'ur', 'urgent', 'us', 'use', 'usf', 'vaguely', 'valid', 'valued',
've', 'vettam', 'wait', 'wales', 'want', 'wanted', 'wap', 'wat', 'watching',
'watts', 'way', 'weak', 'week', 'weekend', 'well', 'wet', 'wif', 'win', 'win
ner', 'wkly', 'wo', 'wonderful', 'wont', 'word', 'words', 'work', 'world',
'worried', 'www', 'xuhui', 'xxx', 'xxxmobilemovieclub', 'yeah', 'yes', 'yumm
y', 'yup', 'ú1']
```

You are given a set of documents in the code below. Calculate the tf-idf matrix and output the score of the term 'belt' in document two.

In [127]:

```
import pandas as pd
from nltk.tokenize import word_tokenize
from nltk.corpus import stopwords
from nltk.stem.porter import PorterStemmer
from sklearn.feature_extraction.text import TfidfVectorizer

# consider the following set of documents
documents = ["The coach lumbered on again, with heavier wreaths of mist closing round it as
             "The guard soon replaced his blunderbuss in his arm-chest, and, having looked
            "For he was furnished with that completeness that if the coach-lamps had been b
            "Jerry, left alone in the mist and darkness, dismounted meanwhile, not only to
            "After standing with the bridle over his heavily-splashed arm, until the wheels


# preprocess document
def preprocess(document):
    'changes document to lower case, removes stopwords and stems words'

    # change sentence to lower case
    document = document.lower()

    # tokenize into words
    words = word_tokenize(document)

    # remove stop words
    words = [word for word in words if word not in stopwords.words("english")]

    # stem
    stemmer = PorterStemmer()
    words = [stemmer.stem(word) for word in words]

    # join words to make sentence
    document = " ".join(words)

    return document

# preprocess documents using the preprocess function and store the documents again in a lis
documents = [preprocess(document) for document in documents] # write code here

# create tf-idf matrix
## write code here ##
vectorizer = TfidfVectorizer()
tfidf_model = vectorizer.fit_transform(documents)
# extract score
score = -1  # replace -1 with the score of 'belt' in document two. You can manually write t

# print the score -- don't change the following piece od code, it's used to evaluate your c
print(round(score, 4))
```

```
-1
```

In [128]:

```
vales = "Vapour, Bangalore has a really great terrace seating and an awesome view of the Ba
documents = [preprocess(document) for document in vales]
```

In [131]:

```
preprocess("The beer at Vapour, Bangalore was amazing. My favourites are the wheat beer and
```

Out[131]:

```
'beer vapour , bangalor amaz . favourit wheat beer ale beer'
```

Document1: "Vapour, Bangalore has a really great terrace seating and an awesome view of the Bangalore skyline" Document2: "The beer at Vapour, Bangalore was amazing. My favourites are the wheat beer and the ale beer." Document3: "Vapour, Bangalore has the best view in Bangalore."

What's the tf-idf score of the term 'beer' in document two? (Remove stop words and punctuations before calculating the tf-idf score). Round your answer to three digits after the decimal.

TF('beer', document1) is 1/3 since there are a total of 9 terms and 'beer' occurs three times. The idf('beer') is log10(3/1) since there are three documents and 'beer' occurs in the second document only. Hence, the total score is tf*idf which is (⅓)*log10(3) which equals 0.159. After rounding to two nearest decimal places, the answer that we get is 0.159

The tf of 'vapour' and 'bangalore' in the second document is equal. The idf of both of these terms is also equal since they have an idf score of zero. Hence, their tf-idf score is also equal.

Note that tf-idf is implemented in different ways in different languages and packages. In the tf score representation, some people use only the frequency of the term, i.e. they don't divide the frequency of the term with the total number of terms. In the idf score representation, some people use natural log instead of the log with base 10. Due to this, you may see a different score of the same terms in the same set of documents. But the goal remains the same - assign a weight according to the word's importance.

In [ ]:

```
```