Lab 2: Natural Language Processing using Python NLTK

Lab Overview

What is NLTK?

Natural Language Toolkit (NLTK) is a leading platform for building Python programs to work with human language data (Natural Language Processing). It is accompanied by a book that explains the underlying concepts behind the language processing tasks supported by the toolkit. NLTK is intended to support research and teaching in NLP or closely related areas, including empirical linguistics, cognitive science, artificial intelligence, information retrieval, and machine learning.

For installation instructions on your local machine, please refer to:

http://www.nltk.org/install.html

http://www.nltk.org/data.html

For a simple beginner Python tutorial take a look at:

http://www.tutorialspoint.com/python/python tutorial.pdf

In this lab we will explore:

- Python quick overview;
- Lexical analysis: Word and text tokenizer;
- n-gram and collocations;
- NLTK corpora;
- Naive Bayes / Decision tree classifier with NLTK.
- Inverted index implementation

Python overview

Basic syntax

Identifiers

Python identifier is a name used to identify a variable, function, class, module, or other object. An identifier starts with a letter A to Z or a to z, or an underscore (_) followed by zero or more letters, underscores and digits (0 to 9). Python does not allow punctuation characters such as @, $, and % within identifiers. Python is a case sensitive programming language. Thus, Variable and variable are two different identifiers in Python.

Lines and Indentation

Python provides no braces to indicate blocks of code for class and function definitions or flow control. Blocks of code are denoted by line indentation, which is rigidly enforced. The number of spaces in the indentation is variable, but all statements within the block must be indented the same amount.

Quotation

Python accepts single (') , double (") and triple (''' or """) quotes to denote string literals, as long as the same type of quote starts and ends the string.

Examples:

```
word = 'word'

sentence = "This is a sentence."

paragraph = """This is a paragraph. It is made up of multiple lines and
sentences."""
```

Data types, assigning and deleting values

Python has five standard data types:

- numbers;
- strings;
- lists;
- tuples;
- dictionaries.

Python variables do not need explicit declaration to reserve memory space. The declaration happens automatically when you assign a value to a variable. The equal sign (=) is used to assign values to variables. The operand to the left of the = operator is the name of the variable and the operand to the right of the = operator is the value stored in the variable.

For example:

```
counter = 100     # An integer assignment

miles = 1000.0    # A floating point

name = "John"     # A string
```

Lists

```
print(len([1, 2, 3]))         # 3 - length

print([1, 2, 3] + [4, 5, 6])  # [1, 2, 3, 4, 5, 6] - concatenation

print(['Hi!'] * 4)            # ['Hi!', 'Hi!', 'Hi!, 'Hi!'] - repetition

print(3 in [1, 2, 3])         # True - checks membership for x in [1, 2, 3]:

print(x)                      # 1 2 3 - iteration
```

Some of the useful built-in functions useful in work with lists are `max`, `min`, `cmp`, `len`, `list` (converts tuple to list), etc. Some of the list-specific functions are `list.append`, `list.extend`, `list.count`, etc.

Tuples

```
tup1 = ('physics', 'chemistry', 1997, 2000)

tup2 = (1, 2, 3, 4, 5, 6, 7)

print(tup1[0]) # prints: physics print(tup2[1:5]) # prints: [2, 3, 4, 5]
```

Basic tuple operations are same as with lists: length, concatenation, repetition, membership and iteration.

Dictionaries

```
dict = {'Name':'Zara', 'Age':7, 'Class':'First'}

dict['Age'] = 8                    # update existing entry

dict['School'] = "DPS School"      # Add new entry

del dict['School']                 # Delete existing entry
```

List comprehension

Comprehensions are constructs that allow sequences to be built from other sequences. Python 2.0 introduced list comprehensions and Python 3.0 comes with dictionary and set comprehensions. The following is the example:

```
 a_list = [1, 2, 9, 3, 0, 4]

squared_ints = [e**2 for e in a_list]

print(squared_ints) # [ 1, 4, 81, 9, 0, 16 ]
```

This is same as:

```
a_list = [1, 2, 9, 3, 0, 4]

squared_ints = []

for e in a_list:

      squared_ints.append(e**2)

print(squared_ints) # [ 1, 4, 81, 9, 0, 16 ]
```

Now, let's see the example with if statement. The example shows how to filter out non integer types from mixed list and apply operations.

```
a_list = [1, '4', 9, 'a', 0, 4]

squared_ints = [ e**2 for e in a_list if type(e) is int ]

print(squared_ints)     # [ 1, 81, 0, 16 ]
```

However, if you want to include if else statement, the arrangement looks a bit different.

```
a_list = [1, ’4’, 9, ’a’, 0, 4]
```

```
squared_ints = [ e**2 if type(e) is int else 'x' for e in a_list]

print(squared_ints)     # [1, 'x', 81, 'x', 0, 16]
```

You can also generate dictionary using list comprehension:

```
a_list = ["I", "am", "a", "data", "scientist"]

science_list = { e:i for i, e in enumerate(a_list) }

print(science_list) # {'I': 0, 'am': 1, 'a': 2, 'data': 3, 'scientist': 4}
```

... or list of tuples:

```
a_list = ["I", "am", "a", "data", "scientist"]

science_list = [ (e,i) for i, e in enumerate(a_list) ]

print(science_list) # [('I', 0), ('am', 1), ('a', 2), ('data', 3),
('scientist’, 4)]
```

String handling

Examples with string operations:

```
str = 'Hello World!'

print(str)              # Prints complete string

print(str[0])           # Prints first character of the string

print(str[2:5])         # Prints characters starting from 3rd to 5th

print(str[2:])          # Prints string starting from 3rd character

print(str*2)            # Prints string two times

print(str + "TEST")     # Prints concatenated string
```

Other useful functions include `join`, `split`, `count`, `capitalize`, `strip`, `upper`, `lower`, etc.

Example of string formatting:

```
print("My name is %s and age is %d!" % ('Zara',21))
```

IO handling

Python has two built-in functions for reading from standard input: `raw_input` and `input`.

```
str = raw_input("Enter your input: ")

print("Received input is : ", str)
```

File opening

To handle files in Python, you can use function open. Syntax:

```
file object = open(file_name [, access_mode][, buffering])
```

One of the useful packages for handling tsv and csv files is csv library.

Functions

An example how to define a function in Python:

```
def functionname(parameters):
      "function_docstring"
      function_suite return [expression]
```

Running your code on VM using Spyder IDE

Step 1. Login to VM and open Spyder IDE

The given VM has Anaconda environment installed along with Python 3.8 and provides Spyder IDE for writing and running python source code.

Step 2. Python list, tuple and dictionary example

Create a file called list `merge.py`. Type the following code and fill in the missing parts (< ... >). Create a dictionary result, where the keys are the values from some list, and values from some tuple. Use list comprehension or standard loop.

```
some_list = ["first_name", "last_name", "age", "occupation"]

some_tuple = ("John", "Holloway", 35, "carpenter")

result = <your code>

print(result)

# {'first_name': 'John', 'last_name': 'Holloway', 'age': 35, 'occupation':
'carpenter'}
```

Submission: Add the code where indicated and submit merge.py to Moodle.

Step 2. Lexical Analysis: tokenization

Word tokenization: A sentence or data can be split into words using the method `word tokenize()`:

```
from nltk.tokenize import sent_tokenize, word_tokenize

data = "All work and no play makes jack a dull boy, all work and no play"

print(word_tokenize(data))
```

This will output:

```
['All', 'work', 'and', 'no', 'play', 'makes', 'jack', 'dull', 'boy', ',',
'all', 'work', 'and', 'no', 'play']
```

All of them are words except the comma. Special characters are treated as separate tokens.

Sentence tokenization: The same principle can be applied to sentences. Simply change the to `sent_tokenize()` We have added two sentences to the variable data:

```
from nltk.tokenize import sent_tokenize, word_tokenize

data = "All work and no play makes jack dull boy. All work and no play makes jack a dull boy."

print(sent_tokenize(data))
```

Outputs:

```
['All work and no play makes jack dull boy.', 'All work and no play makes jack a dull boy.']
```

Storing words and sentences in lists

If you wish to you can store the words and sentences in lists:

```
from nltk.tokenize import sent_tokenize, word_tokenize

data = "All work and no play makes jack dull boy. All work and no play makes jack a dull boy."

phrases = sent_tokenize(data)

words = word_tokenize(data)

print(phrases)

print(words)
```

Step 3. Stop word removal

English text may contain stop words like ‘the’, ‘is’, ‘are’. Stop words can be filtered from the text to be processed. There is no universal list of stop words in NLP research, however the NLTK module contains a list of stop words. Now you will learn how to remove stop words using the NLTK. We start with the code from the previous section with tokenized words.

```
from nltk.tokenize import sent_tokenize, word_tokenize

from nltk.corpus import stopwords   # We imported auxiliary corpus

                                    # provided with NLTK

data = "All work and no play makes jack dull boy. All work and no play makes jack a dull boy."

stopWords = set(stopwords.words('english')) # a set of English stopwords

words = word_tokenize(data.lower())

wordsFiltered = []

for w in words:
```

```
      if w not in stopWords:
            wordsFiltered.append(w)
<your code>                    # Print the number of stopwords
<your code>                    # Print the stopwords
<your code>                    # Print the filtered text ['work', 'play',
'makes', 'jack', 'dull', 'boy', '.', 'work', 'play', 'makes', 'jack', 'dull',
'boy', '.']
```

Submission: Create a file named `stop_word_removal.py` with the previous code snippet and submit it to Moodle.

Step 4. Stemming

A word stem is part of a word. It is sort of a normalization idea, but linguistic. For example, the stem of the word waiting is wait. Given words, NLTK can find the stems. Start by defining some words:

```
words = ["game","gaming","gamed","games"]
```

We import the module:

```
from nltk.stem import PorterStemmer
from nltk.tokenize import sent_tokenize, word_tokenize
```

And stem the words in the list using:

```
from nltk.stem import PorterStemmer
from nltk.tokenize import sent_tokenize, word_tokenize
words = ["game","gaming","gamed","games"]
ps = PorterStemmer()
for word in words:
      print(ps.stem(word))
```

You can do word stemming for sentences too:

```
from nltk.stem import PorterStemmer
from nltk.tokenize import sent_tokenize, word_tokenize
ps = PorterStemmer()
sentence = "gaming, the gamers play games"
words = word_tokenize(sentence)
for word in words:
      print(word + ":" + ps.stem(word))
```

There are more stemming algorithms, but Porter (PorterStemer) is the most popular.

Step 5. n-grams

Word n-grams

```
from nltk import ngrams sentence = "This is my sentence and I want to
ngramize it."

n = 6

w_6grams = ngrams(sentence.split(), n)

for grams in w_6grams:

      print(grams)
```

Character n-grams

```
from nltk import ngrams sentence = "This is my sentence and I want to
ngramize it."

n = 6

c_6grams = ngrams(sentence, n)

for grams in c_6grams:

      print(''.join(grams))
```

Step 6. Exploring corpora

Now, we will use the NLTK corpus module to read the corpus austen-persuasion.txt, included in the Gutenberg corpus collection, and answer the following questions:

- How many total words does this corpus have?
- How many unique words does this corpus have?
- What are the counts for the 10 most frequent words?

Before we proceed with answering these questions, we will describe an NLTK built-in class which can help us to get the answers in a simple way.

FreqDist

When dealing with a classification task, one may ask how can we automatically identify the words of a text that are most informative about the topic and genre of the text? One method would be to keep a tally for each vocabulary item. This is known as a frequency distribution, and it tells us the frequency of each vocabulary item in the text. It is a "distribution" because it tells us how the total number of word tokens in the text are distributed across the vocabulary items. NLTK automates this through FreqDist. Example:

```
from nltk import FreqDist

from nltk.tokenize import word_tokenize
```

```
data = "All work and no play makes jack dull boy. All work and no play makes
jack a dull boy."

words = word_tokenize(data)

fdist1 = FreqDist(words)

print(fdist1.most_common(2))              # Prints two most common tokens

print(fdist1.hapaxes())                   # Prints tokens with frequency 1
```

For the following code snippet fill in the comments with the answers where indicated. For the third question you are asked to report third most common token.

```
from nltk.corpus import gutenberg

from nltk import FreqDist

# Count each token in austen-persuasion.txt of the Gutenberg collection

list_of_words = gutenberg.words("austen-persuasion.txt")

fd = FreqDist(list_of_words) # Frequency distribution object

print("Total number of tokens: " + str(fd.N()))  # <insert_comment_how_many>

print("Number of unique tokens: " + str(fd.B())) # <insert_comment_how_many>

print("Top 10 tokens:")             # <insert_comment_which_is_third token>

for token, freq in fd.most_common(10):

      print(token + "\t" + str(freq))
```

To find out more about FreqDist refer to http://www.nltk.org/book/ch01.html section 3.1.

Submission: Create a file `explore_corpus.py` with the previous code snippet and submit to Moodle.

Step 7. Document Classification

In the previous example we have explored corpus, which, you may have noticed, was imported from nltk.corpus. NLTK offers a package of pre-trained, labeled corpora for different purposes. In this section we will do a simple classification task of movie reviews. The corpus is taken from `nltk.corpus.movie reviews`. The classifier will be `NaiveBayesClassifier`. Create a file `movie_rev_classifier.py` with the following code. Run the code 3 times and report the accuracy for each run. Explain why each time we got different accuracy. Write the comments below the code snippet as a python comment.

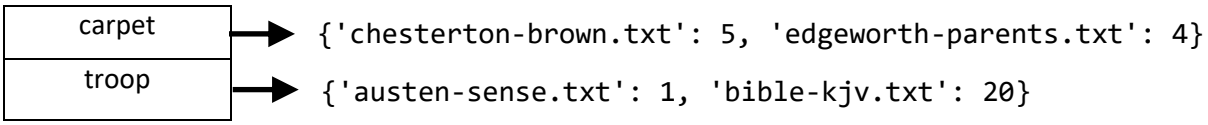
```
from nltk import FreqDist, NaiveBayesClassifier

from nltk.corpus import movie_reviews

from nltk.classify import accuracy

import random

documents = [(list(movie_reviews.words(fileid)), category)
```

```
            for category in movie_reviews.categories()
                  for fileid in movie_reviews.fileids(category)]
random.shuffle(documents) # This line shuffles the order of the documents
all_words = FreqDist(w.lower() for w in movie_reviews.words())
word_features = list(all_words)[:2000]
def document_features(document):
      document_words = set(document)
      features = {}
      for word in word_features:
            features['contains({})'.format(word)] = (word in document_words)
      return features
featuresets = [(document_features(d), c) for (d,c) in documents]
train_set, test_set = featuresets[100:], featuresets[:100] # Split data to
train and test set
classifier = NaiveBayesClassifier.train(train_set)
print(accuracy(classifier, test_set))
# <answer_area>
# <answer_area>
# <answer_area>
```

Submission: Submit the file `movie_rev_classifier.py` to Moodle.

Step 8. Creating inverted Index

In Python, the Inverted Index can be understood as a simple key/value dictionary where per each term (key) we store a list of appearances of those terms in the documents and their frequency. For example, the following inverted index:



contains two terms (carpet and troop) in the lexicon. Each term is connected to its posting list which contains the document names along with the frequency of the term in each document.

The lexicon can be implemented as a python dictionary with key/value pairs where each term can be seen as a key and the term's posting list as a value. The posting list can be also implemented as a python dictionary with filenames and frequencies as key/value pairs.

We provide a python file called `inverted_index.py` which reads all documents within the Gutenberg corpus and builds an inverted index (lexicon and posting lists). Then, it executes two queries:

- Query 1: "`carpet AND troops`" which returns all documents that contain both terms. To find all matching documents using inverted index:
  - Locate carpet in the dictionary
  - Retrieve the documents in its postings list (get the keys of the posting list)
  - Locate troop in the dictionary
  - Retrieve the documents in its postings list (get the keys of the posting list)
  - Intersect the two sets
  - Return intersection
- Query 2: "`carpet AND troop AND NOT overburden`" which returns all documents that contain both terms carpet and troop but not overburden. To find all matching documents using inverted index:
  - Locate carpet in the dictionary
  - Retrieve the documents in its postings list (get the keys of the posting list)
  - Locate troop in the dictionary
  - Retrieve the documents in its postings list (get the keys of the posting list)
  - Locate overburden in the dictionary
  - Retrieve the documents in its postings list (get the keys of the posting list)
  - Intersect the set of documents of carpet and troop
  - Compute difference of the intersection with the overburden documents
  - Return resulting list

You are required to fill the source code where needed (replace the word None).

Submission: Submit the file `inverted_index.py` to Moodle.

Submission

Submit to Moodle the following files:

- `merge.py`
- `stop_word_removal.py`
- `explore_corpus.py`
- `movie_rev_classifier.py`
- `inverted_index.py`

by 1st of October 2020 at 15:00.