COMP348 — Document Processing and the Semantic Web

Week 01 Lecture 2: Text Processing in Python

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Abstract

In this lecture we will do a quick revision of Python and its use for text processing.

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Contents

Reading

- NLTK Chapter 1

Additional Reading

- http://docs.python.org/3/tutorial/index.html

1 A Review of Python

1.1 Practicalities

Why Python

Scripting Language

- Rapid prototyping.
- Platform neutral.

Python

- Even easier prototyping.
  - jupyter notebooks.
- Clean, object oriented.
- Good text manipulation.
- Wide range of libraries.
  - NLTK for NL algorithms.
  - pandas, sklearn, tensorflow for data mining.
  - NumPy and SciPy for scientific computing.
  - matplotlib and pyplot for plotting.

Installing Python

- Official Python at http://www.python.org.
- We will use the Anaconda Python environment from https://www.anaconda.com/distribution/.
- Current version is 3.x *do not use 2.x.*
  - Due to compatibility issues, we will use 3.6 (not the latest version).
- Windows/Mac/Linux versions.
- Download includes many libraries.
  - cgi.
  - email.
  - HTMLParser.
- Anaconda includes Jupyter notebooks and Spyder, a useful IDE.

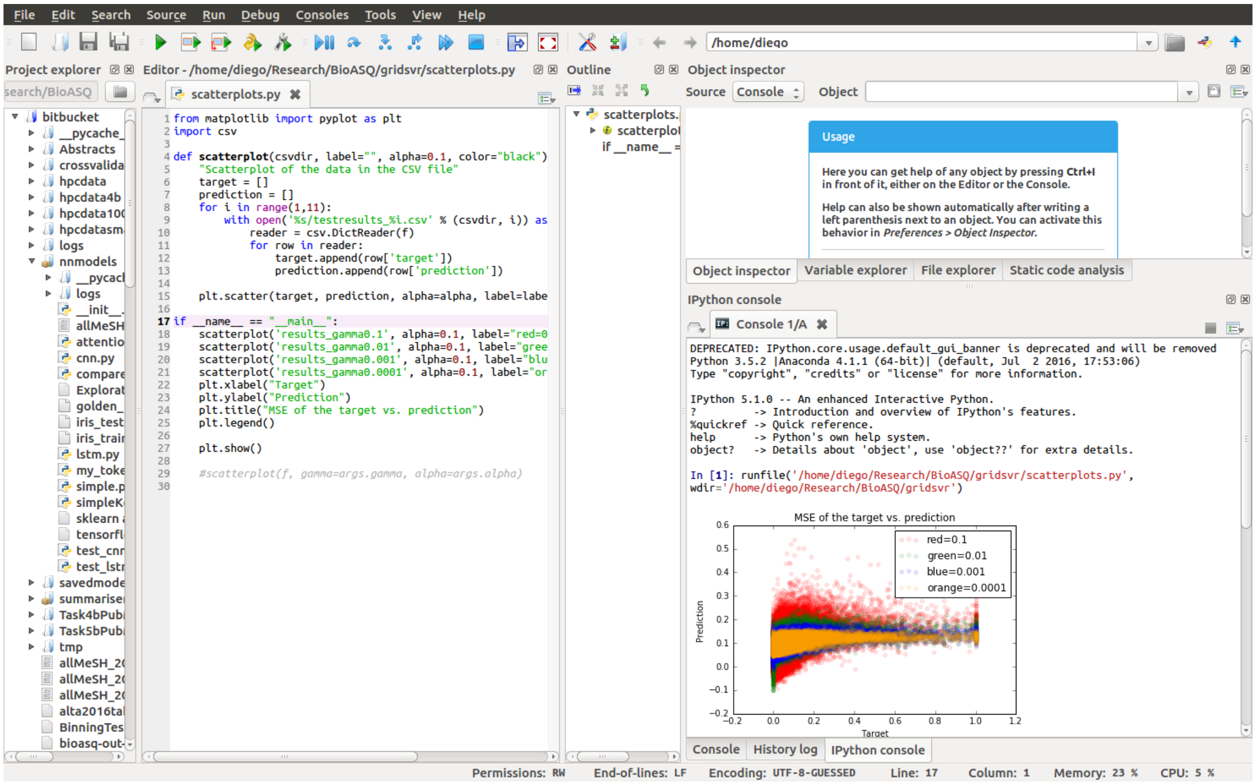
Installing Python 3.6

- Anaconda supports different environments.
- Each environment can have a different Python interpreter.
- The creation of environments and installation of Python packages is managed by conda.
- Full instructions at https://conda.io/projects/conda/en/latest/user-guide/tasks/manage-environments.html

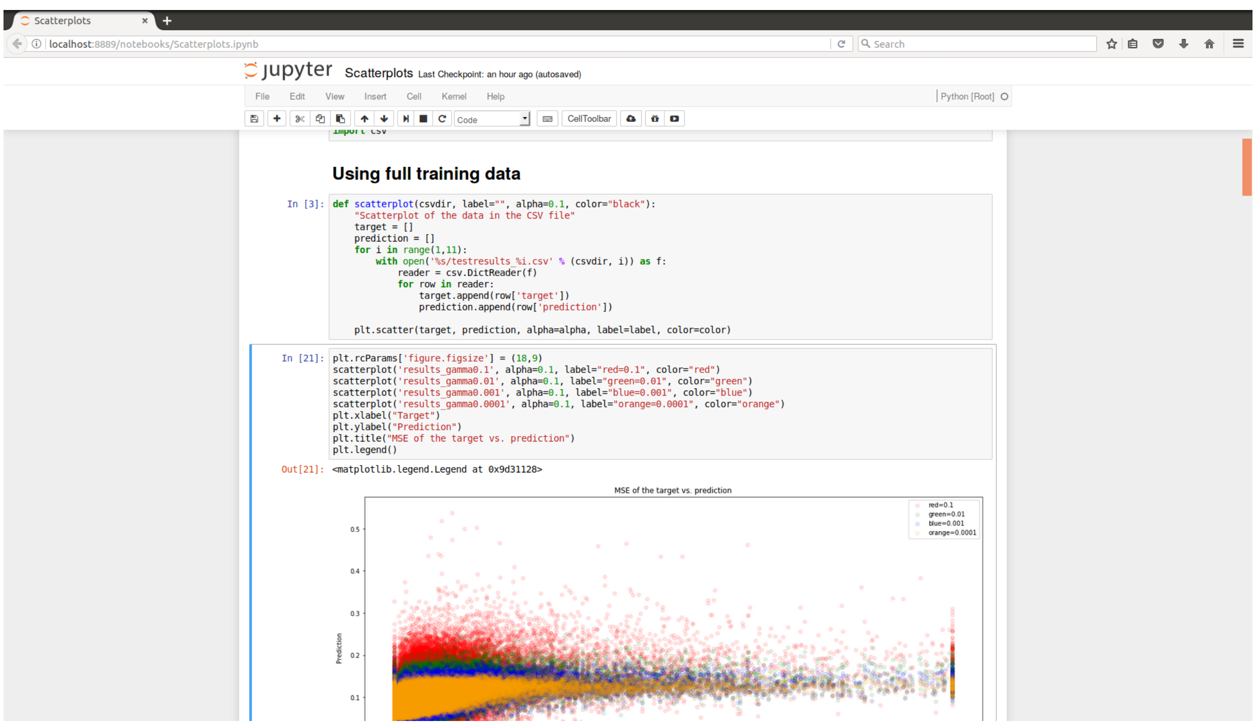
Creating a Python 3.6 Environment

```
$ conda create -n python36 python=3.6
```

Spyder



Jupyter Notebooks



1.2 Basic Python

Beginning Python

This and other Python code available as Jupyter notebooks in github: https://github.com/dmollaaliod/comp348.

```
def hello (who):                              # 1
    """Greet somebody"""                      # 2
    print("Hello " + who + "!")               # 3

hello("Steve")                                # 4
hello('World')                                # 5
people = ['Steve', "Mark", 'Diego']           # 6
for person in people:                         # 7
    hello(person)                             # 8
```

Comments, line per line:

1. Defines a new function/procedure called hello which takes a single argument. Note that python variables are not typed, who could be a string, integer, array ... The line ends with a colon (:) which means we're beginning an indented code block ...
2. Firstly note that there are no brackets delimiting the body of the procedure, Python instead uses indentation to delimit code blocks. So, getting the indentation right is crucial!

   This line (2) is a documentation string for the procedure which gets associated with it in the python environment (IDLE uses it for balloon help). The three double quotes delimit a multi-line string (could use ' or " in this context).
3. This is the body of the procedure, **print** is a built in command in python. Note that the Python 2.x versions do not use round brackets, this is a major difference with Python 3.x. We also see here the + operator used on strings (I'm assuming who is a string) to perform concatenation — thus we have operator overloading based on object type just like other OO languages.
4. Here I'm calling the new procedure with a literal string argument delimited by ".
5. And here delimited by ' — both of these delimiters are equivalent, use one if you want to include the other in the string, eg "Steve's".
6. This defines a variable people to have a value which is a list of strings, lists are 1-D arrays and the elements can be any python object (including lists).
7. A **for** loop over the elements of the list. Again the line ends with a colon indicating a code block to follow.
8. Call the procedure with the variable which will be bound to successive elements of the list.

Core Data Types

- Strings.
- Numbers (integers, float, complex).
- Lists.
- Tuples (immutable sequences).
- Dictionaries (associative arrays).

Lists

```
>>> a = ['one', 'two', 3, 'four']
>>> a[0]
'one'
>>> a[-1]
'four'
>>> a[0:3]
['one', 'two', 3]}
>>> len(a)
4
>>> a[1]=2
>>> a
['one', 2, 3, 'four']
>>> a.append('five')
>>> a
['one', 2, 3, 'four', 'five']
>>> top = a.pop()
>>> a
['one', 2, 3, 'four']
>>> top
'five'
```

List Comprehensions

```
>>> a = ['one', 'two', 'three', 'four']
>>> len(a[0])
3
>>> b = [w for w in a if len(w) > 3]
>>> b
['three', 'four']
>>> c = [[1,'one'],[2,'two'],[3,'three']]
>>> d = [w for [n,w] in c]
>>> d
['one', 'two', 'three']
```

Tuples

- Tuples are a sequence data type like lists but are immutable:
  - Once created, elements cannot be added or modified.
- Create tuples as literals using parentheses:
  a = ('one', 'two', 'three')
- Or from another sequence type:
  a = ['one', 'two', 'three']
  b = **tuple**(a)
- Use tuples as fixed length sequences: memory advantages.

Dictionaries

- Associative array datatype (hash).
- Store values under some hash key.
- Key can be any immutable type: string, number, tuple.

```
>>> names = dict()
>>> names['madonna'] = 'Madonna'
>>> names['john'] = ['Dr.', 'John', 'Marshall']
>>> list(names.keys())
['madonna', 'john']
>>> ages = {'steve':41, 'john':22}
>>> 'john' in ages
True
>>> 41 in ages
False
>>> for k in ages:
...     print(k, ages[k])
steve 41
john 22
```

Organising Source Code: Modules

- In Python, a module is a single source file which defines one or more procedures or classes.
- Load a module with the **import** directive.

```
import mymodule
```

- This loads the file mymodule.py and evaluates its contents.
- By default, all procedures are put into the mymodule namespace, accessed with a dotted notation:
  - mymodule.test() — calls the test() procedure defined in mymodule.py

Modules

- Can import names into global namespace.

```
from mymodule import test, doodle
from mymodule import *
```

- The Python distribution comes with many useful modules.

```
from math import *
x = 20 * log(y)
import webbrowser
webbrowser.open('http://www.python.org')
```

Defining Modules

- A module is a source file containing Python code.
  - Usually class/function definitions.
- First non-comment item can be a docstring for the module.

```
# my python module
"""This is a python module to
do something interesting"""

def foo(x):
    'foo the x'
    print('the foo is ' + str(x))
```

Documentation in Python

- Many Python objects have associated documentation strings.
- Good practice is to use these to document your modules, classes and procedures.
- Docstring can be retrieved as the __doc__ attribute of a module/class/procedure name:

```
def hello (who):
    """Greet somebody"""
    print("Hello " + who + "!")
```

```
>>> hello.__doc__
'Greet somebody'
```

- The function **help**() uses the docstring to generate interactive help.

1.3 Simple Statistics in NLTK

NLTK

What is NLTK?

- Natural Language Toolkit.
- http://www.nltk.org.
- A collection of Python 3 libraries.

Installing NLTK

- http://www.nltk.org/install.html.
- Pre-installed in Anaconda.

Importing NLTK modules

All NLTK modules are under the nltk namespace.

```
>>> import nltk
>>> for id in nltk.corpus.gutenberg.fileids():
...     print(id)
...
austen-emma.txt
austen-persuasion.txt
austen-sense.txt
bible-kjv.txt
blake-poems.txt
bryant-stories.txt
burgess-busterbrown.txt
carroll-alice.txt
chesterton-ball.txt
chesterton-brown.txt
chesterton-thursday.txt
edgeworth-parents.txt
melville-moby_dick.txt
milton-paradise.txt
shakespeare-caesar.txt
shakespeare-hamlet.txt
shakespeare-macbeth.txt
whitman-leaves.txt
```

Counting Words

```
>>> import nltk
>>> emma = nltk.corpus.gutenberg.words('austen-emma.txt')
>>> len(emma)
192427
>>> emma[:10]
['[', 'Emma', 'by', 'Jane', 'Austen', '1816', ']', 'VOLUME', 'I', 'CHAPTER']
>>> import collections
>>> emma_counter = collections.Counter(emma)
>>> emma_counter.most_common(10)
[(',', 11454), ('.', 6928), ('to', 5183), ('the', 4844),
('and', 4672), ('of', 4279), ('I', 3178), ('a', 3004),
('was', 2385), ('her', 2381)]
```

Comments

We say emma_counter('Emma') and not emma_counter('Emma'). What is happening here is that the class Counter can be indexed like a list (or more exactly, like a dictionary).

Exercises

1. Find the most frequent word with length of at least 7 characters.
2. Find the words that are longer than 7 characters and occur more than 7 times.

Counting Bigrams

A bigram is a sequence of two words.

```
>>> list(nltk.bigrams([1,2,3,4,5,6]))
[(1, 2), (2, 3), (3, 4), (4, 5), (5, 6)]
>>> list(nltk.bigrams(emma))[:3]
[('[', 'Emma'), ('Emma', 'by'), ('by', 'Jane')]
```

Exercises

1. Find the most frequent bigram.
2. Find the most frequent bigram that begins with "the".

Ngrams

- A bigram is an ngram where n is 2.
- A trigram is an ngram where n is 3.

```
>>> list(nltk.ngrams(emma,4))[:5]
[('[', 'Emma', 'by', 'Jane'),
 ('Emma', 'by', 'Jane', 'Austen'),
 ('by', 'Jane', 'Austen', '1816'),
 ('Jane', 'Austen', '1816', ']'),
 ('Austen', '1816', ']', 'VOLUME')]
```

2 Text Processing with Python

2.1 Sorting

Sorting

- The function **sorted**() returns a sorted copy.
- Sequences can be sorted in place with the sort() method.
- Python 3 does not support sorting of lists with mixed contents.

```
>>> foo = [2,5,9,1,11]
>>> sorted(foo)
[1, 2, 5, 9, 11]
>>> foo
[2, 5, 9, 1, 11]
>>> foo.sort()
>>> foo
[1, 2, 5, 9, 11]
>>> foo2 = [2,5,9,1,'a']
>>> sorted(foo2)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unorderable types: str() < int()
```

Example

```
>>> l = ['a','abc','b','c','aa','bb','cc']
>>> sorted(l)
['a', 'aa', 'abc', 'b', 'bb', 'c', 'cc']
>>> sorted(l,key=len)
['a', 'b', 'c', 'aa', 'bb', 'cc', 'abc']
>>> sorted(l,key=len,reverse=True)
['abc', 'aa', 'bb', 'cc', 'a', 'b', 'c']
>>> sorted(l,key=lambda x: -len(x))
['abc', 'aa', 'bb', 'cc', 'a', 'b', 'c']
```

Notes

- The last example is a lambda expression that creates a function on the fly, without giving it a name.

Exercises

You're given data of the following form:

```
namedat = dict()
namedat['mc'] = ('Madonna', 45)
namedat['sc'] = ('Steve', 41)
```

1. How would you print a list ordered by name?

```
('Madonna', 45)
('Steve', 41)
```

2. How would you print out a list ordered by age?

```
('Steve', 41)
('Madonna', 45)
```

2.2 String Handling

Strings in Python

- String is a base datatype.
- Strings are sequences and can use operations like:
  - foo = "A string"
  - **len**(foo)
  - foo[0]
  - foo[0:3]
  - multifoo = *"""A multiline*
    string"""
- In addition, there are some utility functions in the string module.

Some Useful String Functions

```
>>> "my string".capitalize()
'My string'
>>> "my string".upper()
'MY STRING'
>>> "My String".lower()
'my string'
>>> a = "my string with my other text"
>>> a.count('my')
2
>>> a.find('with')
10
>>> a.find('nothing')
-1
```

Split

- split (sep) is a central string operation.
- It splits a string wherever sep occurs (blank space by default).
- It is either a function in the string module or a method of string objects.

```
>>> foo="one :: two :: three"
>>> foo.split()
['one', '::', 'two', '::', 'three']
>>> foo.split('::')
['one ', ' two ', ' three']
>>> import string
>>> string.split("this is a test")
['this', 'is', 'a', 'test']
```

Join

- Join is another useful function/method in the string module.
- It takes a list and joins the elements using some delimiter.

```
>>> text="this is some text to analyse"
>>> words=text.split()
>>> words.sort()
>>> print(",".join(words))
analyse,is,some,text,this,to
>>> print("".join(words))
analyseissometextthisto
```

Replace

```
def censor(text):
    'replace bad words in a text with XXX'
    badwords = ['poo', 'bottom']
    for b in badwords:
        text = text.replace(b, 'XXX')
    return text
```

2.3 Text Preprocessing with NLTK

NLTK Packaged Tools

Some NLTK tools that are useful for text pre-processing are:

- word_tokenize(text)
- sent_tokenize(text)
- pos_tag(tokens)
- pos_tag_sents(sentences)
- PorterStemmer()

Sentence and Work Tokenisation with NLTK

- NLTK can split text into sentences and words.
  - Sentence segmentation splits text into a list of sentences.
  - Word tokenisation splits text into a list of words (tokens).
- NLTK's default word tokeniser works best after splitting the text into sentences.

```
In [1]: import nltk

In [2]: text = "This is a sentence. This is another sentence."

In [3]: nltk.sent_tokenize(text)
Out[3]: ['This is a sentence.', 'This is another sentence.']

In [4]: for s in nltk.sent_tokenize(text):
   ...:     for w in nltk.word_tokenize(s):
   ...:         print(w)
   ...:     print()
   ...:
This
is
a
sentence
.

This
is
```

```
another
sentence
.
```

Part of Speech Tagging

- Often it is useful to know whether a word is a noun, or an adjective, etc. These are called parts of speech.
- NLTK has a part of speech tagger that tags a list of tokens.
- The default list of parts of speech is fairly detailed but we can set a simplified version (called universal by NLTK).

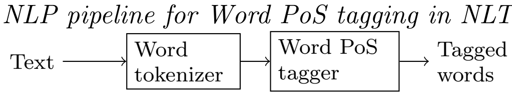
Tag	Meaning	English Examples
ADJ	adjective	new, good, high, special, big, local
ADP	adposition	on, of, at, with, by, into, under
ADV	adverb	really, already, still, early, now
CONJ	conjunction	and, or, but, if, while, although
DET	determiner, article	the, a, some, most, every, no, which
NOUN	noun	year, home, costs, time, Africa
NUM	numeral	twenty-four, fourth, 1991, 14:24
PRT	particle	at, on, out, over per, that, up, with
PRON	pronoun	he, their, her, its, my, I, us
VERB	verb	is, say, told, given, playing, would
.	punctuation marks	. , ; !
X	other	ersatz, esprit, dunno, gr8, univeristy

NLP Pipelines

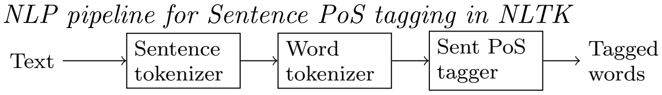
Often, text processing works in pipelines.

- The output of one module is used as the input to the following module.

NLP pipeline for Word PoS tagging in NLTK



NLP pipeline for Sentence PoS tagging in NLTK



Note that the above pipelines may differ in other environments.

Examples in Python

```
In [28]: nltk.pos_tag(["this", "is", "a", "test"])
Out[28]: [('this', 'DT'), ('is', 'VBZ'), ('a', 'DT'), ('test', 'NN')]

In [29]: nltk.pos_tag(["this", "is", "a", "test"], tagset="universal")
Out[29]: [('this', 'DET'), ('is', 'VERB'), ('a', 'DET'), ('test', 'NOUN')]
```

```
In [30]: nltk.pos_tag(nltk.word_tokenize("this is a test"), tagset="universal")
Out[30]: [('this', 'DET'), ('is', 'VERB'), ('a', 'DET'), ('test', 'NOUN')]

In [31]: text
Out[31]: 'This is a sentence. This is another sentence.'

In [34]: text_sent_tokens = [nltk.word_tokenize(s) for s in nltk.sent_tokenize(t
    ...: ext)]

In [35]: text_sent_tokens
Out[35]:
[['This', 'is', 'a', 'sentence', '.'],
 ['This', 'is', 'another', 'sentence', '.']]

In [38]: nltk.pos_tag_sents(text_sent_tokens, tagset="universal")
Out[38]:
[[('This', 'DET'),
  ('is', 'VERB'),
  ('a', 'DET'),
  ('sentence', 'NOUN'),
  ('.', '.')],
 [('This', 'DET'),
  ('is', 'VERB'),
  ('another', 'DET'),
  ('sentence', 'NOUN'),
  ('.', '.')]]
```

Stemming

- Often it is useful to remove information such as verb form, or the difference between singular and plural.
- NLTK offers stemming, which removes suffixes.
  - The Porter stemmer is a popular stemmer.
- The remaining stem is not a word but can be used, for example, by search engines (we'll see more of this in another lecture).

Examples of NLTK's Porter Stemmer

```
In [46]: s = nltk.PorterStemmer()

In [47]: s.stem("books")
Out[47]: 'book'

In [48]: s.stem("is")
Out[48]: 'is'

In [50]: s.stem("runs")
Out[50]: 'run'
```

```
In [51]: s.stem("running")
Out[51]: 'run'

In [52]: s.stem("run")
Out[52]: 'run'

In [53]: s.stem("goes")
Out[53]: 'goe'
```

Exercises

1. What is the sentence with the largest number of tokens in Austen's "Emma"?
2. What is the most frequent part of speech in Austen's "Emma"?
3. What is the number of distinct stems in Austen's "Emma"?
4. What is the most ambiguous stem in Austen's "Emma"? (meaning, which stem in Austen's "Emma" maps to the largest number of distinct tokens?)

Take-home Messages

- Get to know nltk.
- Practice with NLP pipelines.
- Do the exercises listed in the lecture notes.

What's Next

Week 2

- Information Retrieval

Additional Reading

- "Introduction to Information Retrieval", http://www-nlp.stanford.edu/IR-book/