Lab 2: Exploring corpus data with Python and matplotlib

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This lab is available as a web page[2] or pdf document[3].

Goals and motivation of this lab

In Lab 1 we saw that you can do some basic exploration of language data using only UNIX commands, but in general you will want to go further. Using Python we can write more complex functions that process multiple files, and we will also see how to visualize the data using Matplotlib library functions. We have also included several questions to get you thinking about the linguistic data and what it means, which is important even if you already know how to do the programming parts!

The example functions and plots used in this lab will start to give you a basis for lots of other functions and plots you may need to write later, either for homework assignments in this class, for other classes, or for your projects over the summer. (These really are only a start; we'll continue developing more plotting skills next week.)

Because some students are still Python beginners, we have written most of the code here already and have added a lot of comments explaining how it works. You'll have a chance to modify some of the code to help you understand it better.

For students who are more experienced programmers: please note that we have tried to keep the coding style here very simple, and have avoided some of the more advanced language features of Python. However, see the 'Going Further' section at the end if you want to try your hand at using some of those features.

Preliminaries

This lab will be using the same data set as Lab 1. If you didn't download the data already, please do so following the instructions in *Creating your lab directory* and *Downloading the data* from Lab 1[4]. Below we will assume the data is located in your lab1 directory.

Now, create a directory for this lab inside the `labs` directory you made last week (or in the previous step), and cd into that directory:

```
cd ~/anlp/labs
mkdir lab2
cd lab2
```

Download the file lab2.py[5] into your `lab2` directory: From the Lab 2 web page[2], right-click on the link and select *Save link as...*, then navigate to your lab2 directory to save.

[1] http://creativecommons.org/licenses/by-nc/4.0/.

[2] http://www.inf.ed.ac.uk/teaching/courses/anlp/labs/lab2.html

[3] http://www.inf.ed.ac.uk/teaching/courses/anlp/labs/lab2.pdf

[4] http://www.inf.ed.ac.uk/teaching/courses/anlp/labs/lab1.html

[5] http://www.inf.ed.ac.uk/teaching/courses/anlp/labs/lab2.py

Next, open the file using your favorite text editor. If you don't have one, we suggest gedit.

```
gedit lab2.py &
```

If using gedit, you will want to set auto-indenting so that hitting <enter> will automatically insert enough spaces to line up your cursor with the line above (useful for Python coding). If you need to indent further, e.g. starting a loop, you will need to type 4 spaces.

Set auto-indent using the menu Edit->Preferences, go to the Editor tab and tick "Enable automatic indentation".

Examining and running the code

Before doing anything with the code, let's take a quick look at it first. You will see that there are some `import` statements at the top; if you are new to Python you should read the comments in the code that explain what they do, though you need not do so right now. (Comments are enclosed in triple quotes `'''` or begin with a hash mark #.)

In the main part of the file there are several function definitions, which we will explore in more detail in the rest of the lab, and a block of code that gets command line arguments and calls the functions, as we'll explain in a moment.

Running code in iPython

As you may already know, there are different ways to run Python code. The first way you probably learned was to type directly into an *interpreter* such as Idle. In this class, we will use the iPython interpreter. To start the interpreter, just type the following into a terminal:

```
ipython
```

You should get a `In [1]:` prompt, and can now do things like this (where the `Out` line is the interpreter's response):

```
In [1]: 3+4
Out[1]: 7
```

Later, when you want to exit iPython, type `exit()`.

If you have a whole file of code, as we do here, you could just cut and paste some/all of the file into the interpreter, but that's unwieldy. iPython provides us with a convenient way to do the same thing without pasting. Try typing this into the interpreter:

```
%run lab2.py
```

(Note: commands that start with '%' are specific to iPython, and may not work in other Python interpreters).

What happened? Can you see which line of code in lab2.py generated the message you got?

You can also run the code from the terminal. Verify this by typing the following in a terminal window:

```
python lab2.py
```

You should see the same message you got before. But, the advantage of using `%run` inside iPython is that after running the code, we still have access to all the variables and functions defined in it, which we do not have if we run the code in the terminal. To see how this works, go back to the interpreter and try this:

```
%run lab2.py ../lab1/Providence/Ethan/eth01.cha ../lab1/Providence/Ethan/eth02.cha
```

Note: you can use tab completion in iPython just like in a UNIX terminal. In fact you can also use lots of other UNIX commands like `ls`, `pwd`, *etc. Again, this functionality is specific to iPython and may not work in other interpreters.*

You should see a plot pop up on the screen. We will come back to the plot in a moment, so for now just close that window (otherwise you will not be able to type anything further into the interpreter).

Since you now have access to the variables defined in lab2.py, try typing `fnames` in the interpreter. What is the value of this variable?

In case you are wondering, `fnames` was set using the special variable `sys.argv`, which gets set automatically to be the list of arguments provided at the terminal or `%run` command (with `sys.argv[0]` being the program name, here `lab2.py`, and the rest of the items in the list being any remaining arguments, in this case the filenames).

Now, *without* looking at the value of the `word_counts` variable, can you figure out what data type it is? *(Hint: look at the comments and/or code in the "get_word_counts" function).*

Once you have figured that out, you should be able to get the count of the word 'the'. What is it?

Getting help in iPython (and in general)

Before moving on, let's make sure you know how to get help. There are several ways to do this:

1. Simply type `help()` at the iPython interpreter prompt; you can then type a module name (e.g., `string`) and you will get some documentation. Actually a *lot* of documentation, but maybe not the most helpful kind. So, it may be better to try options 2 or 3. (Hit `q` to exit help.)

2. To get a list of all the methods available for a particular variable, you can use tab completion in iPython. This can also work to tell you all the methods available for particular datatype, like a string. For example, type the following two lines into the interpreter, but don't hit <enter> after the second line:

   ```
   str = "a string"
   str.
   ```

   Now type <tab>. You should see a list of all of the methods you can call on `str`, which is to say, all the methods for strings.

3. Often it's most appropriate to just search the Internet, if you want more general information, don't know the name of the function you're looking for, want examples of how to use particular functions, or whatever.

4. A final point: `help` also works for functions defined in your own code, if you have written documentation for them. Try typing `help(zipf_plot)`. Notice where the documentation comes from in the code we wrote in lab2.py.

Looking at the data

The code we have given you is actually not quite correct. Let's try to figure out what is wrong and how to fix it. First, create a plot like the one we saw before but this time using only one file:

```
%run lab2.py ../lab1/Providence/Ethan/eth01.cha
```

First, compare the left-hand (linear) and right-hand (log) plots. Notice that on the linear plot it is nearly impossible to see what's going on except for the very top-ranked words. Those words are so much more frequent than anything else that on the linear axes, almost all the words are compressed into a tiny portion of the plot. You will also see that there are huge differences in frequency between the top few words; as you look further down the list, closely ranked words have more similar frequencies.

Do you see anything funny in the Zipf plot? If you're not sure yet, try checking some of the following. These are all good things to sanity check whenever you are looking at language data:

- How many unique word types are there? (Use the `len` function).
- What are the first few and last few words as sorted alphabetically? (Use the `sorted` function and list indexing to look at only part of the list)
- What are the first few and last few words as sorted by frequency? (To sort the *keys* in a dictionary, say `mydict`, according to the *values* of the keys, you can do this:

  ```
  sorted(mydict, key=mydict.get)
  ```

  Create your own tiny dictionary called `mydict` to verify this.)

- If you have some previous programming/Python experience (don't try this otherwise), an even better thing to do is to modify the zipf_plot function so that the words themselves show up as the x-axis labels. You'll need to use the `xticks` function from matplotlib (Google it), and you can zoom in on just the top-ranked words by using the optional maxRank argument to zipf_plot. (Of course, this won't help you debug anything that's wrong with lower ranked words).

Hopefully by this time you will have noticed some problems with the data in `word_counts`. If you re-create the Zipf plot, can you see where these problems are showing up?

Fixing the problem

Now that you have identified what's wrong with `word_counts`, you should be able to make some very small changes to the `get_word_counts` function that fix the problems, at least mostly. There may still be a few things in `word_counts` that you don't consider real words. What are some of those things? [The question of what counts as a word and what doesn't comes up a lot in NLP, and there is rarely a single correct answer; often we need to use our judgment and justify our decisions.]

After making your changes to `get_word_counts`, re-run the code. Does the plot look any better now? Go back and do the sanity checks in the previous section again to make sure you didn't miss anything else. You can also try running the code with a larger number of files, e.g.:

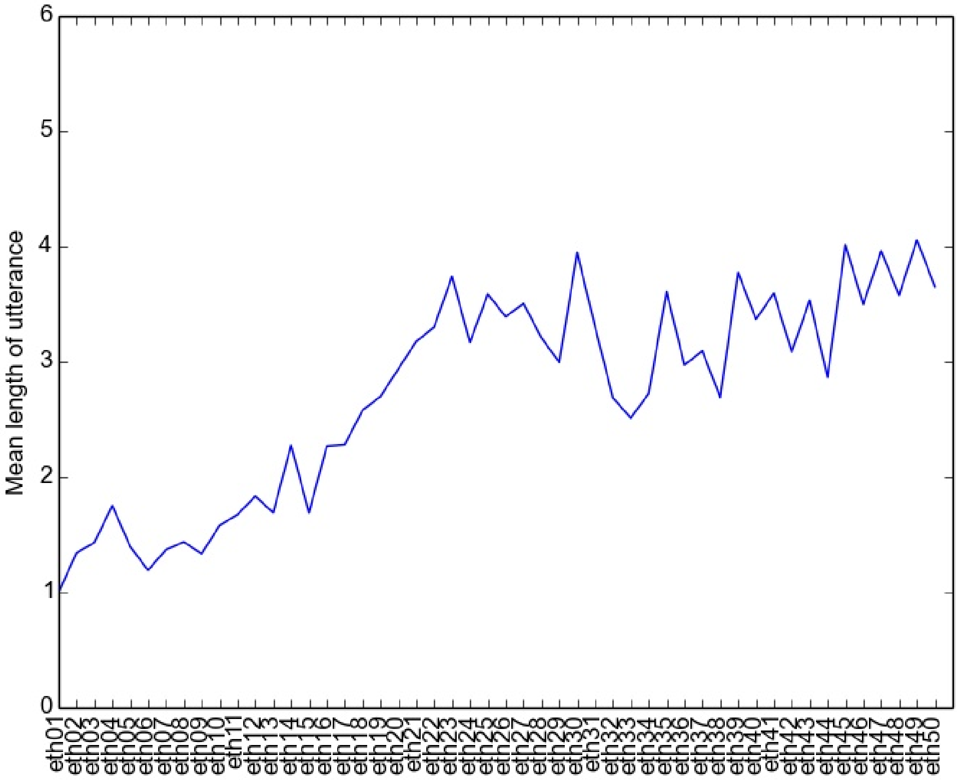
```
%run lab2.py ../lab1/Providence/Ethan/eth*.cha
```

The plot should look similar but smoother than it does with only one or two files. Why is it smoother?

MLU

Before going further, take a look at the `get_mlus` function and make sure you understand what it is doing. What do the variables `ntoks` and `nutts` represent? Can you explain the line where `ntoks` gets incremented and why there is a *-3* there?

Now, remove or comment out the line of code that creates the zipf plot, and replace it with code that creates a graph of MLUs. You will need to use the `get_mlus` function, and also fill in the `plot_mlus` function, which currently does nothing. Use `short_fnames` as the labels for the MLU plot, so it should end up looking something like the one below if you run on the Ethan data. (Hint: look at the plotting functions in zipf_plot for examples, and also Google the Matplotlib documentation for `plot` and `xticks`. You are only making 1 plot, so you don't need the `subplot` command).



Once your plot looks right, save it as a PDF file, so you can create and compare plots across a few different children. What general trends do you see in the plots and why? Why are the plots so jagged? Suppose we wanted to use this data to directly compare the language development of the different children, i.e., whether one child is acquiring language faster than another. What information is missing from the plots you just made that would be needed in order to do this analysis?

Going Further

Have a go at some or all of the following. You may need to do some legwork to look up how to use the functions or techniques that are mentioned. Tasks 1-3 are less challenging from a programming perspective but are still good for getting you to think about the data some more. Task 4 may require a bit more programming but should also be accessible to beginners.

1. Compute type/token ratios for the mothers and children in the corpus. (The type/token ratio is simply the number of unique word types divided by the number of word tokens, where in this case we would like you to compute the ratio for each mother and each child separately.) Do you see any consistent patterns? How would you illustrate or describe these patterns effectively to someone else?

2. Generalize `get_mlus` to take a second argument that is a string. The new version should compute MLU for lines beginning with that string (e.g., you should be able to compute the MLU for MOT instead of CHI). Use Matplotlib's `subplot` function to plot the MLU of MOT and CHI from the same set of files in a single plot. Do you see the same trends in the MOT and CHI data? Discuss why or why not.

3. Further improve the tokenization in `get_word_counts` so that the word counts you are collecting more accurately reflect "real" words.

4. The information needed to make a fair comparison between children's language development is already in the files we gave you. Write some new code that generates MLU plots using this information, and see what you can conclude about the development of each child.

5. Rewrite `get_mlus` without using `for` loops by instead using list comprehension. (This exercise is mainly intended for students who are experienced programmers but new to Python.)

6. Download the Manchester corpus from CHILDES, which contains morphological annotations, and see if you can compute MLU based on the number of morphemes per utterance instead of the number of words per utterance. (Warning: you will likely run into various unanticipated issues in processing the data, this is par for the course in NLP)