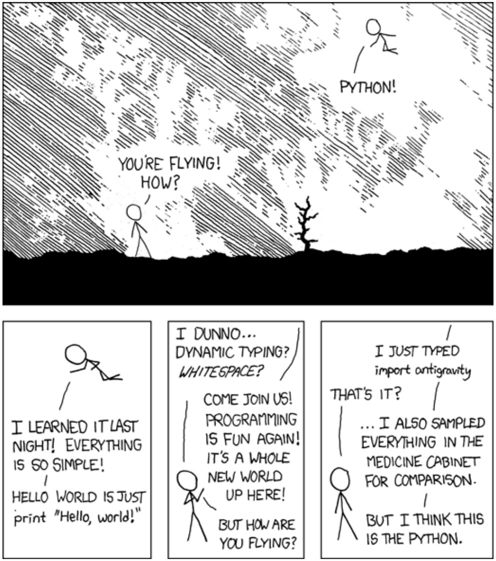
Programming with Python

EOAS Software Carpentry Workshop

September 21st, 2016


PYTHON!
YOU'RE FLYING! HOW?
I LEARNED IT LAST NIGHT! EVERYTHING IS SO SIMPLE!
HELLO WORLD IS JUST print "Hello, world!"
I DUNNO... DYNAMIC TYPING? WHITESPACE?
COME JOIN US! PROGRAMMING IS FUN AGAIN! IT'S A WHOLE NEW WORLD UP HERE!
BUT HOW ARE YOU FLYING?
I JUST TYPED import antigravity
THAT'S IT?
... I ALSO SAMPLED EVERYTHING IN THE MEDICINE CABINET FOR COMPARISON.
BUT I THINK THIS IS THE PYTHON.

https://xkcd.com/353

Getting started

For our Python introduction we're going to pretend to be a researcher studying inflammation in patients who have been given a new treatment for arthritis.

You need to download some files to follow this lesson:

1. Make a new folder in your Desktop called `python-novice-inflammation`.
2. Download python-novice-inflammation-data.zip and move the file to this folder.
3. If it's not unzipped yet, double-click on it to unzip it. You should end up with a new folder called data.
4. You can access this folder from the Unix shell with:

```
$ cd && cd Desktop/python-novice-inflammation/data
```

Launching Jupyter Notebook

There are several ways that we can use Python. We're going to start with a tool called Jupyter Notebook that runs in the browser. In a shell window enter these commands:

```
$ cd
$ cd Desktop/python-novice-inflammation/data
$ jupyter notebook
```

The shell window is now running a local web server for you. Don't close it. You will need to open another shell window to do other command line things. Your browser should open to an "Jupyter: Notebook" page showing a list of directories.

Analyzing patient data

1. Explain what a library is, and what libraries are used for.
2. Load a Python library and use the things it contains.
3. Read tabular data from a file into a program.
4. Assign values to variables.
5. Select individual values and subsections from data.

- import numpy
- numpy.loadtxt(fname= delimiter=)
- weight_kg = 55
- print('weight in kg:', weight_kg)
- weight_lb = 2.2 * weight_kg

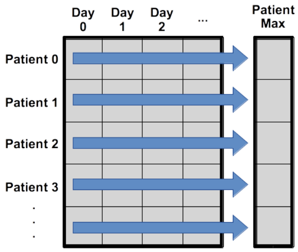
- type(data)
- data.shape
- data[0,0], data[0:1,0:1]
- data[0:10:2,1]
- data[:3,36:]

Analyzing Patient Data cont'd

6. Perform operations on arrays of data.
7. Display simple graphs.

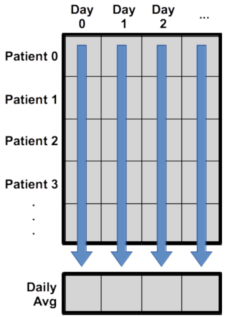
- data.mean()
- data.std()
- data.mean(axis=0)
- %matplotlib inline
- from matplotlib import pyplot
- pyplot.imshow(data)
- pyplot.show()
- pyplot.plot(ave_inflammation)
- import matplotlib import pyplot as plt
- plt.subplot(1,3,1)
- plt.ylabel('average')
- plt.show()

Operations across an axis



Max for each patient

`data.max(axis=1)`



Average for each day

`data.mean(axis=0)`

Exercise

Create a single plot showing 1) the mean for each day and 2) the mean + 1 standard deviation for each day and 3) the mean - 1 standard deviation for each day.

Repeating actions with loops

1. Explain what a for loop does.
2. Correctly write for loops to repeat simple calculations.
3. Trace changes to a loop variable as the loop runs.
4. Trace changes to other variables as they are updated by a for loop.

- for char in word:
- len('aeiou')

Python has a built-in function called range that creates a list of numbers: range(3) produces [0, 1, 2], range(2, 5) produces [2, 3, 4], and range(2, 10, 3) produces [2, 5, 8]. Using range, write a loop that prints the first three natural numbers:

```
1
2
3
```

Python has a built-in function called range that creates a list of numbers: range(3) produces [0, 1, 2], range(2, 5) produces [2, 3, 4], and range(2, 10, 3) produces [2, 5, 8]. Using range, write a loop that prints the first three natural numbers:

One solution:

```
for num in range(1,4,1):
 print(num)
```

Exponentiation is built into Python:

```
print(5**3)
125
```

Write a loop that calculates the same result using multiplication (without exponentiation).

Exponentiation is built into Python:

```
print(5**3)
125
```

Write a loop that calculates the same result using multiplication (without exponentiation)

One possible answer:

```
ans=1
for ii in range(1,4,1):
 ans=ans*5
print(ans)
```

Storing Multiple Values in Lists

Learning Goals

1. Explain what a list is.
2. Create and index lists of simple values.

Lesson Commands

- `odds = [1, 3, 5, 7]`
- `print(odds[0], odds[-1])`
- `for number in odds:`
- `names[1] = 'Darwin'`
- `odds.append(11)`
- `del odds[0]`
- `odds.reverse()`

Exercise

Turn a String into a List

Use a for loop to convert the string `'hello'` into a list of letters:

```
['h', 'e', 'l', 'l', 'o']
```

Hint: You can create an empty list like this:

```
my_list = []
```

Storing Multiple Values in Lists

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Lesson Commands

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- `print(odds[0], odds[-1])`
- `for number in odds:`
- `names[1] = 'Darwin'`
- `odds.append(11)`
- `del odds[0]`
- `odds.reverse()`

Analyzing Data from Multiple Files

Learning Goals

1. Use a library function to get a list of filenames that match a simple wildcard pattern.
2. Use a for loop to process multiple files.

Lesson Commands

- `import glob`
- `filenames = glob.glob('*.csv')`
- `filenames[0:3]`

Making Choices

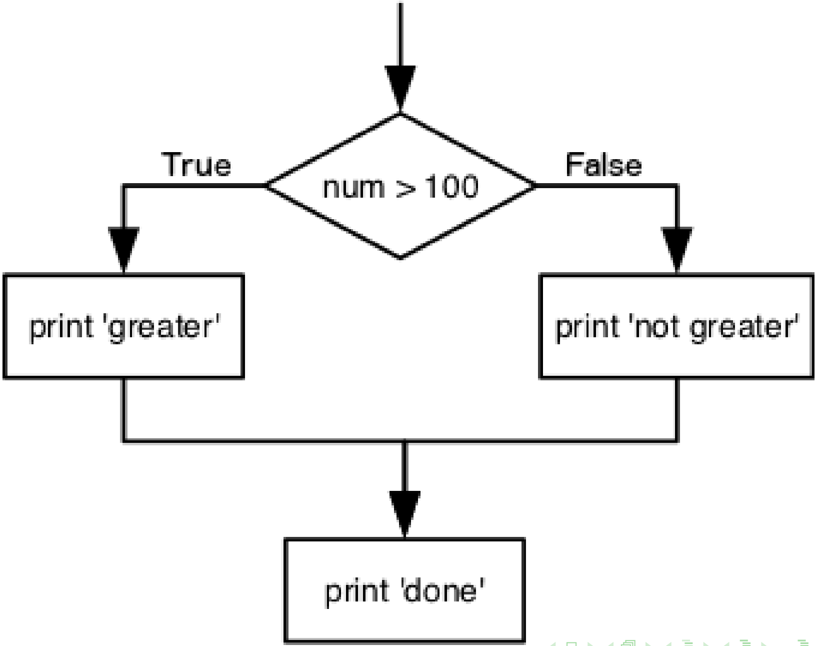
Learning Goals

1. Explain the similarities and differences between tuples and lists.
2. Write conditional statements including ‘if‘, ‘elif‘, and ‘else‘ branches.
3. Correctly evaluate expressions containing ‘and‘ and ‘or‘.

Lesson Commands

- `if num > 100:`
- `else:`
- `if num > 0:`
- `elif num == 0:`
- `and`
- `or`

Python if/else Flowchart



Exercise

How Many Paths?

What will be printed if you run this code:

```
if 4 > 5:
 print('A')
elif 4 == 5:
 print('B')
elif 4 < 5:
 print('C')
```

1. A
2. B
3. C
4. B and C

Why did you pick your answer?

Exercise

Close Enough

Work with your partner to write some code that will print `True` if the value of variable `a` is within 10% of the value of variable `b` and `False` otherwise. Test your code for positive values, negative values, and values that span zero.

Making Choices

Learning Goals

1. Explain the similarities and differences between tuples and lists.
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Lesson Commands

- `if num > 100:`
- `else:`
- `if num > 0:`
- `elif num == 0:`
- `and`
- `or`

Creating Functions - Defining a Function

Learning Goals

1. Explain why we should divide programs into small, single-purpose functions.
2. Define a function that takes parameters.
3. Return a value from a function.

Example Code

-
  ```
  def fahr_to_kelvin(temp):
       return ((temp - 32) * (5/9)) + 273.15
  ```

-
  ```
  def kelvin_to_celsius(temp):
      return temp - 273.15
  ```

-
  ```
  def fahr_to_celsius(temp):
      temp_k = fahr_to_kelvin(temp)
      result = kelvin_to_celsius(temp_k)
      return result
  ```

Exercise

Write a function called analyze that takes a filename as a parameter and displays the three graphs produced in the previous lesson, i.e., analyze('inflammation-01.csv') should produce the graphs already shown, while analyze('inflammation-02.csv') should produce corresponding graphs for the second data set. Hint: a function can just “do” something. It doesn't necessarily need to return anything.

Solution

```
def analyze(filename):
    data = np.loadtxt(fname=filename, delimiter=',')
    fig = plt.figure(figsize=(10.0, 3.0))

    axes1 = fig.add_subplot(1, 3, 1)
    axes2 = fig.add_subplot(1, 3, 2)
    axes3 = fig.add_subplot(1, 3, 3)

    axes1.set_ylabel('average')
    axes1.plot(data.mean(axis=0))

    axes2.set_ylabel('max')
    axes2.plot(data.max(axis=0))

    axes3.set_ylabel('min')
    axes3.plot(data.min(axis=0))

    fig.tight_layout()
    plt.show(fig)
```

Defining a Function

```
def detect_problems(filename):

    data = np.loadtxt(fname=filename, delimiter=',')

    if data.max(axis=0)[0] == 0 and data.max(axis=0)[20] ==
        print('Suspicious looking maxima!')
    elif data.min(axis=0).sum() == 0:
        print('Minima add up to zero!')
    else:
        print('Seems OK!')
```

Testing and Documentation

Learning Goal

3. Test and debug a function.

Example Code

-
  ```
  def centre(data, desired):
      return (data - data.mean()) + desired
  ```
- `z = numpy.zeros((2,2))`
- `print centre(z, 3)`
- `print data.std() - centred.std()`

-
  ```
  def center(data, desired):
    '''Return a new array containing the original data
       centered around the desired value.'''
    return (data - data.mean()) + desired
  ```
- `help(centre)`

Defining Defaults

Learning Goals

6. Set default values for function parameters.

Example Code

- `def center(data, desired = 0):`
-
  ```
  def display(a=1, b=2, c=3):
      print 'a:', a, 'b:', b, 'c:', c
  print 'no parameters:'
  display()
  print 'one parameter:'
  display(55)
  print 'two parameters:'
  display(55, 66)
  ```
- help(numpy.loadtxt)

Exercise

“Adding” two strings produces their concatenation: `’a’ + ’b’` is `’ab’`. Write a function called fence that takes two parameters called original and wrapper and returns a new string that has the wrapper character at the beginning and end of the original. A call to your function should look like this:

```
print(fence(’name’, ’*’))
*name*
```

Exercise

"Adding" two strings produces their concatenation: `'a' + 'b'` is `'ab'`. Write a function called fence that takes two parameters called original and wrapper and returns a new string that has the wrapper character at the beginning and end of the original. A call to your function should look like this:

```
print(fence('name', '*'))
*name*
```

Solution

```
def fence(original, wrapper):
    '''Returns a string with charcter wrapper added to the
       beginning and end of string original.'''

       return wrapper + original + wrapper
```

Tracebacks and Exceptions

Learning Goals

1. Read a traceback, and determine the following relevant pieces of information:
   - The file, function, and line number on which the error occurred
   - The type of the error
   - The error message
2. Describe the types of situations in which the following errors occur:
   - `SyntaxError` and `IndentationError`
   - `NameError`
   - `IndexError`
   - `FileNotFoundError`

Exercise

Does this code raise an exception? If so, what is the name of the exception?

```
for x in range(10, -10, -1):
    print('inverse of', x, 'is', 1/x)
```

Can you modify the code so that it does what is intended, but avoids the exception?

Try/Except Blocks

Learning Goals

1. Write error handling Python code using `try` and `except` statements.

Lesson Commands

```
try:
    # something that might go wrong
except SomeError:
    # handle the error
```

Command-line programs

Learning goals

1. Use the values of command-line arguments in a program.
2. Handle flags and files separately in a command-line program.
3. Read data from standard input in a program so that it can be used in a pipeline.

Commands and functions

```
sys.version
sys.argv
sys.stdin
```

Switching to shell commands

$ in front of a command that tells you to run that command in the shell rather than the Python interpreter

- Rewrite `readings.py` so that it uses `-n`, `-m`, and `-x` instead of `--min`, `--mean`, and `--max` respectively. Is the code easier to read? Is the program easier to understand?
- Separately, modify `readings.py` so that if no action is given it displays the means of the data.