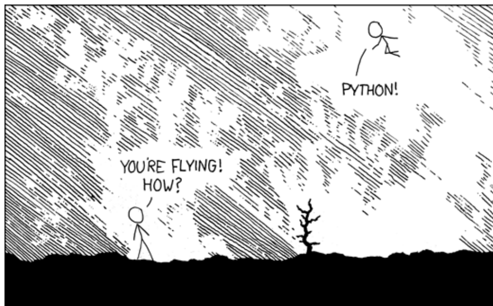
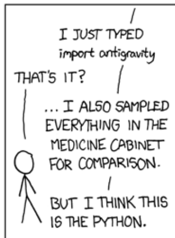
Programming with Python

EOAS Software Carpentry Workshop

September 21st, 2016





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

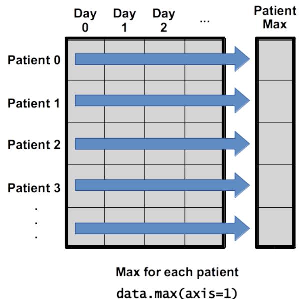
- type(data)
- data.shape
- data[0,0], data[0:1,0:1]
- data[0:10:2,1]
- data[:3,36:]

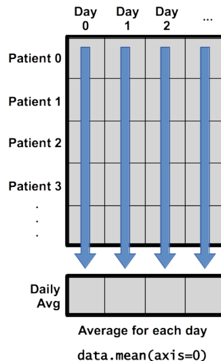
Analyzing Patient Data cont'd

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





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

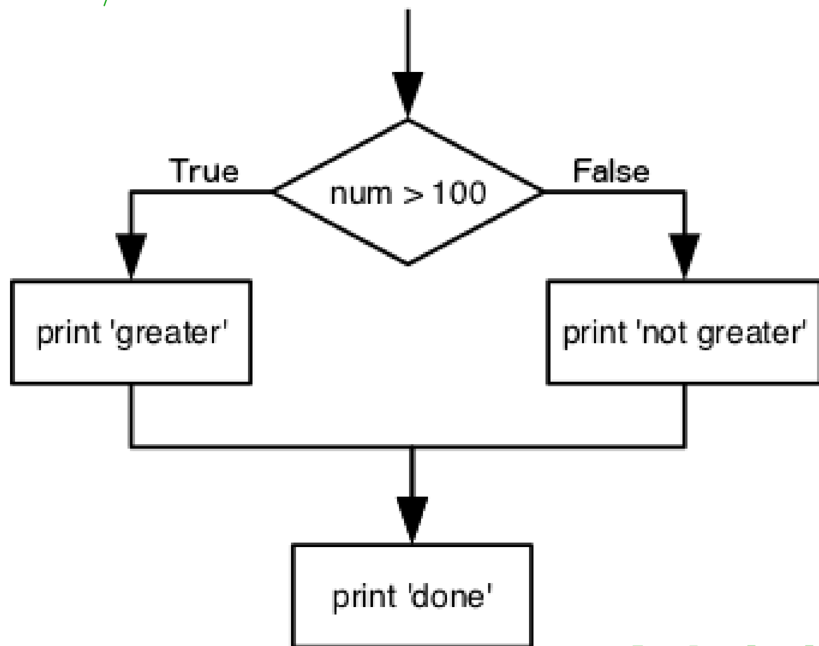
Learning Goals

1. Write conditional statements including ‘if‘, ‘elif‘, and ‘else‘ branches.
2. 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

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2. Correctly evaluate expressions containing ‘and‘ and ‘or‘.

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.