

# iPython

# The SciPy Stack

SciPy is a Python-based ecosystem of libraries and tools for scientific computing and data analytics

- ▶ iPython
- ▶ Jupyter notebooks
- ▶ Numpy
- ▶ Pandas
- ▶ Matplotlib

iPython is the primary way of interacting with the SciPy stack – whether through the shell or a Jupyter notebook. It's also a fantastic REPL.

# iPython

Two modes:

- ▶ Interactive shell
  - ▶ Replacement for `python` REPL
- ▶ Jupyter notebook
  - ▶ Interactive web-based documents mixing text, executable code, graphics

Before we proceed, make sure your computer is ready (OS shell):

```
1 $ pip install ipython
```

# iPython Shell History

```
1 In [1]: ['Sage', 'Thyme', 'Oragano', 'Posh']
2 Out[1]: ['Sage', 'Thyme', 'Oragano', 'Posh']
3
4 In [2]: type(In[1])
5 Out[2]: str
6
7 In [3]: type(Out[1])
8 Out[3]: list
9
10 In [4]: spices = Out[1]
11
12 In [5]: spices
13 Out[5]: ['Sage', 'Thyme', 'Oragano', 'Posh']
14
15 In [6]: spices is Out[1]
16 Out[6]: True
```

In is a list, Out is a dict.

# iPython Help

Single ? gives abbreviated version of python's `help`

```
1 In [7]: def add(a, b):
2     ...:     """Return the result of + operation on a and b"""
3     ...:     return a + b
4     ...:
5 In [8]: add?
6 Signature: add(a, b)
7 Docstring: Return the result of + operation on a and b
8 File:      ~/cs2316/<ipython-input-7-af5293282e78>
9 Type:      function
```

Double ?? gives source code, if available.

```
1 In [9]: add??
2 Signature: add(a, b)
3 Source:
4 def add(a, b):
5     """Return the result of + operation on a and b"""
6     return a + b
7 File:      ~/cs2316/<ipython-input-7-af5293282e78>
8 Type:      function
```

# iPython Magic Commands

Special commands provided by iPython, prepended by %.

► Run a Python script from within iPython:

```
1 In [35]: %run people.py
2 [<Stan, 2008-08-13, 150cm, 45kg>,
3  <Kyle, 2008-02-25, 160cm, 50kg>,
4  <Cartman, 2008-05-26, 140cm, 100kg>,
5  <Kenny, 2009-07-30, 130cm, 40kg>]
```

► Get help with a magic command with ?

```
1 In [2]: %cd?
2 Docstring:
3 Change the current working directory.
4
5 (content elided)
6
7 Usage:
8
9     cd 'dir': changes to directory 'dir'.
10 (additional output elided)
```

Get a list of all magic commands with %lsmagic

# iPython Shell Commands

Run shell commands by prepending with a !

```
1 In [27]: !ls *.py
2 fun.py    grades.py  maths.py   people.py  pp.py
3
4 In [28]: pyscripts = !ls *.py
5
6 In [29]: pyscripts
7 Out[29]: ['fun.py', 'grades.py', 'maths.py', 'people.py', 'pp.py']
```

iPython provides magic commands for most common shell commands.

# iPython Direcotry Bookmarking

Great timesaving feature: bookmark directories

```
1 In [3]: %pwd
2 Out[3]: '/home/chris/vcs/github.com/cs2316/cs2316.github.io/code'
3
4 In [4]: %cd
5 /home/chris
6
7 In [5]: %bookmark cs2316code
8         `chris/vcs/github.com/cs2316/cs2316.github.io/code
9
10 In [6]: cd cs2316code
11 (bookmark:cs2316code) ->
12         `chris/vcs/github.com/cs2316/cs2316.github.io/code
13 /home/chris/vcs/github.com/cs2316/cs2316.github.io/code
```



# iPython Automagic commands

With `automagic` turned on, some shell commands can be run as if they were built into iPython:

```
1 In [22]: pwd
2 Out[22]: '/Users/chris/cs2316'
3
4 In [23]: ls *.py
5 fun.py    grades.py maths.py people.py pp.py
```

- ▶ Toggle automagic on and off with `%automagic`.
- ▶ These commands work with automagic:
  - ▶ `%cd`, `%cat`, `%cp`, `%env`, `%ls`, `%man`, `%mkdir`, `%more`, `%mv`, `%pwd`, `%rm`, and `%rmdir`

# Timing Code in iPython

```
1 In [23]: import numpy as np
2
3 In [24]: pylist = list(range(1, 100000))
4
5 In [25]: nparray = np.arange(1, 1000000)
6
7 In [35]: %timeit _ = [x * 2 for x in pylist]
8 100 loops, best of 3: 7.89 ms per loop
9
10 In [37]: %timeit _ = nparray.copy() * 2
11 100 loops, best of 3: 3.76 ms per loop
```

Notice that I copied the Numpy array before applying the `* 2` operation to make the comparison to the Python list comprehension fair. You'll learn why when we discuss Numpy in the next lecture.

# Profiling a Script

```
1 In [7]: %run -p -l 10 -s cumulative funcalc.py
2         2673375 function calls (1147466 primitive calls) in 1.691
           seconds
3
4 Ordered by: cumulative time
5 List reduced from 56 to 10 due to restriction <10>
6
7 ncalls tottime percall cumtime percall filename:lineno(function)
8      2/1    0.000    0.000    1.691    1.691 {built-in method
           builtins.exec}
9          1    0.000    0.000    1.691    1.691 <string>:1(<module>)
10         1    0.000    0.000    1.691    1.691
           interactiveshell.py:2431(safe_execfile)
11         1    0.000    0.000    1.691    1.691 py3compat.py:182(execfile)
12         1    0.000    0.000    1.690    1.690 funcalc.py:1(<module>)
13         1    0.000    0.000    1.689    1.689 funcalc.py:46(main)
14         1    0.039    0.039    1.689    1.689 funcalc.py:34(profile)
15 510961/10000 0.510    0.000    0.603    0.000 funcalc.py:14(sub)
16 510961/10000 0.514    0.000    0.598    0.000 funcalc.py:6(add)
17 510961/10000 0.340    0.000    0.340    0.000 funcalc.py:22(mult)
```

- ▶ `-p` means profile
- ▶ `-l 10` means show only 10 lines
- ▶ `-s cumulative` means sort by cumulative time

# Profiling a Function

`%prun` profiles a function. Uses same options as `% run -p`.

```
1 In [10]: %prun -l 10 -s cumulative funcalc.profile()
2          2673429 function calls (1148052 primitive calls) in 1.726
           seconds
3
4 Ordered by: cumulative time
5 List reduced from 15 to 10 due to restriction <10>
6
7 ncalls tottime percall cumtime percall filename:lineno(function)
8      1      0.000      0.000      1.726      1.726 {built-in method
           builtins.exec}
9      1      0.000      0.000      1.726      1.726 <string>:1(<module>)
10     1      0.042      0.042      1.726      1.726 funcalc.py:34(profile)
11 511231/10000 0.537      0.000      0.620      0.000 funcalc.py:6(add)
12 511231/10000 0.523      0.000      0.615      0.000 funcalc.py:14(sub)
13 511231/10000 0.336      0.000      0.336      0.000 funcalc.py:22(mult)
14    20000    0.019      0.000      0.097      0.000 random.py:223(randint)
15    501231    0.092      0.000      0.092      0.000 funcalc.py:15(dec)
16    501231    0.082      0.000      0.082      0.000 funcalc.py:7(inc)
17    20000    0.036      0.000      0.078      0.000 random.py:179(randrange)
```