Chapter1

December 30, 2018

1 IPython:

. . IPython (Emacs Atom) . IPython((Interactive Python)) 2001 (Fernando Perez) , ‘ (Research Computing) ’ . IPython . IPython . . IPython , , Jupyter . IPython Julia, R, Jupyter . . IPython . IPython . IPython , . ’ ’ . .

1.0.1 , ?

IPython IPython IPython . . IPython IPython . #### Ipython . . . (command line) ipython IPython . EPD (3’IPython ’). IPython . #### Jupyter Jupyter IPython , . /IPython / , , . . IPython , . ’(kernel)’ . $ jupyter notebook . . URL . . . #### IPython . IPython . , . . (?) , (Stack Overflow) . . IPython/Jupyter . , IPython . IPython . * ? ? * ? * ? ? IPython . ? ??, . #### ? , . (docstring) . help() . , len .

```
In [1]: help(len)
```

```
Help on built-in function len in module builtins:

len(obj, /)
    Return the number of items in a container.
```

. IPython ? .

```
In [3]: len?
```

```
In [4]: L=[1, 2, 3]
        L.insert?
```

```
In [5]: L?
```

```
In [6]: def square(a):
            """a  """
            return a**2
```

```
In [7]: square?
```

?? . IPython (??) .

```
In [8]: square??
```

. ?? ?? . C . ?? ? . . len .

```
In [9]: len??
```

? ?? .

IPython , (Tab) . . #### . help dir . (.) .

```
In [10]: L.count
```

```
Out[10]: <function list.count(value, /)>
```

(public)/ (private)/ , . .

```
In [11]: L.__add__
```

```
Out[11]: <method-wrapper '__add__' of list object at 0x000001F6148035C8>
```

(double-underscore methods, 'dender').

. itertools co .

```
In [13]: from itertools import combinations
         import Crypto
```

: . , IPython '*' . Warning .

```
In [14]: *Warning?
```

```
In [1]: str.*find*?
```

.

1.1 IPython

. ctrl-C ctrl-V (Ctrl-C Ctrl-V) . . Emacs, Vim . Ipython . IPython GNU Readline . . , IPython . . Emacs . , , , .

. * Ctrl -a * Ctrl -e * Ctrl-b( ) * Ctrl-f( )

(Backspace) . IPython . . Ctrl-b Ctrl-d ! * Ctrl - d * Ctrl - k * Ctrl - u * Ctrl - y () * Ctrl - t

IPython . IPython IPython SQLite . / . * Ctrl-p( ) * Ctrl-n( ) * Ctrl-r . square . IPython . IPython Ctrl-r IPython .

. * Ctrl-l * Ctrl-c * Ctrl-d IPython Ctrl-c . . .

1.2 IPython

IPython . IPython . IPython (magic commands) , % . . . % (line magics) %% (cell magics) . . #### : %paste %cpaste IPython (interptreter marker) . . .

```
In [4]: def donothing(x):
            return x

In [6]: %paste
        def donothing(x):
            return x

UsageError: Line magic function `%paste` not found.


In [7]: %run Untitled.ipynb

Help on built-in function len in module builtins:

len(obj, /)
    Return the number of items in a container.



UsageError: Line magic function `%paste` not found.


In [8]: %timeit L = [n ** 2 for n in range(1000)]

353 ţs ś 7.62 ţs per loop (mean ś std. dev. of 7 runs, 1000 loops each)


In [9]: %%timeit
        L=[]
        for n in range(1000):
            L.append(n**2)

392 ţs ś 14.1 ţs per loop (mean ś std. dev. of 7 runs, 1000 loops each)
```

```
In [10]: %timeit?

In [11]: %magic

In [12]: %lsmagic

Out[12]: Available line magics:
         %alias  %alias_magic  %autocall  %automagic  %autosave  %bookmark  %cd  %clear  %cls

         Available cell magics:
         %%!  %%HTML  %%SVG  %%bash  %%capture  %%cmd  %%debug  %%file  %%html  %%javascript  %

         Automagic is ON, % prefix IS NOT needed for line magics.
```

1.3 /

```
In [13]: import math

In [14]: math.sin(2)

Out[14]: 0.9092974268256817

In [15]: math.cos(2)

Out[15]: -0.4161468365471424

In [16]: print(In)

['', "get_ipython().run_line_magic('psearch', 'str.*find*')", 'def donothing(x):\n    return %

In [17]: Out

Out[17]: {12: Available line magics:
         %alias  %alias_magic  %autocall  %automagic  %autosave  %bookmark  %cd  %clear  %cls

         Available cell magics:
         %%!  %%HTML  %%SVG  %%bash  %%capture  %%cmd  %%debug  %%file  %%html  %%javascript  %

         Automagic is ON, % prefix IS NOT needed for line magics.,
          14: 0.9092974268256817,
          15: -0.4161468365471424}

In [18]: print(In[1])

get_ipython().run_line_magic('psearch', 'str.*find*')

In [22]: print(_)
```

```
-0.4161468365471424
```

```
In [23]: print(__)
```

```
0.9092974268256817
```

```
In [25]: math.sin(2) + math.cos(2);
```

%history . %history? . %rerun( ) %save( ) .

```
In [26]: %history
```

```
str.*find*?
def donothing(x):
    return %x
def donothing(x):
    return %x
def donothing(x):
    return x
%paste
%paste
def donothing(x):
    return x
%run Untitled.ipynb
%timeit L = [n ** 2 for n in range(1000)]
%%timeit
L=[]
for n in range(1000):
    L.append(n**2)
%timeit?
%magic
%lsmagic
import math
math.sin(2)
math.cos(2)
print(In)

Out
print(In[1])
print(Out[2])
print(Out[4])
print(Out[0])
print(_)
print(__)
Out[2]
math.sin(2) + math.cos(2);
%history
```

1.4 IPython

. IPython IPython . . ! .
OS X . .(2016 [Bash shell] !). (Software Carpentry Foundation) #### ?
// , . . 1980 . , . . . , . . . IT ,
. . /OS X (osx:~ $ $, #).

```
In [4]: %echo "hello world"

"hello world"
```

```
In [2]: %pwd

Out[2]: 'C:\\Users\\Mir\\Python\\RTOS\\Python_Data_Science_Handbook'
```

```
In [5]: %ls

 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook

2018-12-30   04:40    <DIR>          .
2018-12-30   04:40    <DIR>          ..
2018-12-28   12:53    <DIR>          .idea
2018-12-28   11:34    <DIR>          .ipynb_checkpoints
2018-12-28   02:12             7,732 Overview.ipynb
2018-12-28   12:53               715 temp.ipynb
2018-12-30   04:40            39,844 Untitled.ipynb
               3                48,291
               4   57,470,730,240
```

```
In [6]: %cd fdfd

[WinError 2]     : 'fdfd'
C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook
```

```
In [7]: %mkdir test

In [8]: %ls

 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook

2018-12-30   04:42    <DIR>          .
```

```
2018-12-30   04:42    <DIR>          ..
2018-12-28   12:53    <DIR>          .idea
2018-12-28   11:34    <DIR>          .ipynb_checkpoints
2018-12-28   02:12             7,732 Overview.ipynb
2018-12-28   12:53               715 temp.ipynb
2018-12-30   04:42    <DIR>          test
2018-12-30   04:42            42,164 Untitled.ipynb
               3               50,611
               5   57,470,386,176
```

```
In [9]: %rmdir test
```

```
In [10]: %ls
```

```
 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook

2018-12-30   04:43    <DIR>          .
2018-12-30   04:43    <DIR>          ..
2018-12-28   12:53    <DIR>          .idea
2018-12-28   11:34    <DIR>          .ipynb_checkpoints
2018-12-28   02:12             7,732 Overview.ipynb
2018-12-28   12:53               715 temp.ipynb
2018-12-30   04:42            42,164 Untitled.ipynb
               3               50,611
               4   57,470,300,160
```

IPython IPython ! . ls, pwd, echo !ls, !pwd, !echo . #### Ipython IPython . , .

```
In [11]: contents = %ls

         print(contents)

         directory = %pwd

         print(directory)
```

```
 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook

2018-12-30   04:44    <DIR>          .
```

```
2018-12-30   04:44    <DIR>          ..
2018-12-28   12:53    <DIR>          .idea
2018-12-28   11:34    <DIR>          .ipynb_checkpoints
2018-12-28   02:12             7,732 Overview.ipynb
2018-12-28   12:53               715 temp.ipynb
2018-12-30   04:44            44,755 Untitled.ipynb
               3               53,202
               4   57,471,414,272
None
C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook
```

```
In [13]: type(directory)
```

```
Out[13]: str
```

, grep, fields , s, n , p . IPython . , {varname} .

```
In [14]: message = "hello from python"
```

```
         %echo {message}
```

```
hello from python
```

.

1.5

IPython !cd .

```
In [15]: %pwd
```

```
Out[15]: 'C:\\Users\\Mir\\Python\\RTOS\\Python_Data_Science_Handbook'
```

```
In [16]: %cd ..
```

```
C:\Users\Mir\Python\RTOS
```

```
In [17]: %pwd
```

```
Out[17]: 'C:\\Users\\Mir\\Python\\RTOS'
```

```
In [18]: %cd Python_Data_Science_Handbook/
```

```
C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook
```

. %cd . , % . automagic , %automagic . %cd %cat, %cp, %env, %ls, %man, %mkdir, %more, %mv, %pwd, %rm, %rmdir automagic % . IPython .

```
In [19]: mkdir tmp

In [20]: ls

 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook

2018-12-30   04:52    <DIR>          .
2018-12-30   04:52    <DIR>          ..
2018-12-28   12:53    <DIR>          .idea
2018-12-28   11:34    <DIR>          .ipynb_checkpoints
2018-12-28   02:12             7,732 Overview.ipynb
2018-12-28   12:53               715 temp.ipynb
2018-12-30   04:52    <DIR>          tmp
2018-12-30   04:52            50,174 Untitled.ipynb
               3               58,621
               5   57,467,863,040


In [25]: %copy myproject.txt tmp/

    .


In [28]: %ls tmp

 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook\tmp

2018-12-30   04:52    <DIR>          .
2018-12-30   04:52    <DIR>          ..
               0                   0
               2   57,467,662,336


In [30]: %rmdir tmp

In [31]: %ls

 C    .
   : 96EB-D514

 C:\Users\Mir\Python\RTOS\Python_Data_Science_Handbook

2018-12-30   04:53    <DIR>          .
```

```
2018-12-30   04:53    <DIR>          ..
2018-12-28   12:53    <DIR>          .idea
2018-12-28   11:34    <DIR>          .ipynb_checkpoints
2018-12-28   02:12             7,732 Overview.ipynb
2018-12-28   12:53               715 temp.ipynb
2018-12-30   04:52            50,174 Untitled.ipynb
               3              58,621
               4   57,467,629,568
```

.

1.6

, IPython . . #### :%xmode . traceback . %xmode IPython . .

```
In [32]: def func1(a, b):
             return a/b
         def func2(x):
             a = x
             b = x - 1
             return func1(a, b)

In [33]: func2(1)
```

```
---------------------------------------------------------------------------
ZeroDivisionError                         Traceback (most recent call last)

<ipython-input-33-7cb498ea7ed1> in <module>()
----> 1 func2(1)


<ipython-input-32-ecc22e732938> in func2(x)
      4     a = x
      5     b = x - 1
----> 6     return func1(a, b)


<ipython-input-32-ecc22e732938> in func1(a, b)
      1 def func1(a, b):
----> 2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1


ZeroDivisionError: division by zero
```

func2 , . . %xmode (exception mode[ ]) . %xmode , Plain, Context, Verbose . Context . Plain .

```
In [34]: %xmode Plain

Exception reporting mode: Plain


In [35]: func2(1)


        Traceback (most recent call last):


          File "<ipython-input-35-7cb498ea7ed1>", line 1, in <module>
        func2(1)


          File "<ipython-input-32-ecc22e732938>", line 6, in func2
        return func1(a, b)


          File "<ipython-input-32-ecc22e732938>", line 2, in func1
        return a/b


        ZeroDivisionError: division by zero
```

Verbos .

```
In [36]: %xmode Verbose

Exception reporting mode: Verbose


In [37]: func2(1)


        ---------------------------------------------------------------------------

        ZeroDivisionError                         Traceback (most recent call last)

        <ipython-input-37-7cb498ea7ed1> in <module>()
    ----> 1 func2(1)
            global func2 = <function func2 at 0x000001E95C7B0378>
```

```
        <ipython-input-32-ecc22e732938> in func2(x=1)
          4     a = x
          5     b = x - 1
    ----> 6     return func1(a, b)
            global func1 = <function func1 at 0x000001E95C7B0A60>
            a = 1
            b = 0


        <ipython-input-32-ecc22e732938> in func1(a=1, b=0)
          1 def func1(a, b):
    ----> 2     return a/b
            a = 1
            b = 0
          3 def func2(x):
          4     a = x
          5     b = x - 1


        ZeroDivisionError: division by zero
```

. Verbose ? . Default .

: pdb. . IPython IPython (IPython debugger) ipdb. . . IPython %debug . . ipdb ! (a b quit) .

```
In [38]: %debug

> <ipython-input-32-ecc22e732938>(2)func1()
      1 def func1(a, b):
----> 2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1

ipdb> print(a)
1
ipdb> print(b)
0
ipdb> quit
```

. .

```
In [39]: %debug

> <ipython-input-32-ecc22e732938>(2)func1()
      1 def func1(a, b):
```

```
----> 2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1

ipdb> up
> <ipython-input-32-ecc22e732938>(6)func2()
      2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1
----> 6     return func1(a, b)

ipdb> print(x)
1
ipdb> up
> <ipython-input-37-7cb498ea7ed1>(1)<module>()
----> 1 func2(1)

ipdb> down
> <ipython-input-32-ecc22e732938>(6)func2()
      2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1
----> 6     return func1(a, b)

ipdb>
> <ipython-input-32-ecc22e732938>(2)func1()
      1 def func1(a, b):
----> 2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1

ipdb> quit
```

. %pdb .

```
In [40]: %xmode Plain

Exception reporting mode: Plain


In [41]: %pdb on

Automatic pdb calling has been turned ON
```

```
In [42]: func2(1)

         Traceback (most recent call last):


           File "<ipython-input-42-7cb498ea7ed1>", line 1, in <module>
         func2(1)


           File "<ipython-input-32-ecc22e732938>", line 6, in func2
         return func1(a, b)


           File "<ipython-input-32-ecc22e732938>", line 2, in func1
         return a/b


         ZeroDivisionError: division by zero



> <ipython-input-32-ecc22e732938>(2)func1()
      1 def func1(a, b):
----> 2     return a/b
      3 def func2(x):
      4     a = x
      5     b = x - 1

ipdb> print(b)
0
ipdb> quit
```

%run - d next .

```
In [43]: %xmode Verbose

Exception reporting mode: Verbose


In [44]: %pdb off

Automatic pdb calling has been turned OFF
```

1.7

. . (Donald Knuth) " 97% . ." . , . IPython . IPython

- %time
- %tiemit
- %prun
- %lprun (line-by-line profiler)
- %memit
- %mprun (line-by-line memory profiler)

IPython line_profiler memory_profiler .

: %timeit %time 13 'IPython ' %timeit %%tiemit . %%timeit (code snippet) .

```
In [45]: %timeit sum(range(100))

1.2 ţs ś 12.2 ns per loop (mean ś std. dev. of 7 runs, 1000000 loops each)
```

%timeit . , %timeit .

```
In [50]: %%timeit
         total = 0
         for i in range(1000):
             for j in range(1000):
                 total += i * (-1) ** j

432 ms ś 4.47 ms per loop (mean ś std. dev. of 7 runs, 1 loop each)
```

. , . .

```
In [51]: import random
         L = [random.random() for i in range(100000)]
         %timeit L.sort()

535 ţs ś 39 ţs per loop (mean ś std. dev. of 7 runs, 1000 loops each)
```

%time . . .

```
In [52]: import random
         L = [random.random() for i in range(100000)]
         print("   :")
         %time L.sort()

   :
Wall time: 17 ms
```

```
In [53]: print("   :")
         %time L.sort()
```

:

```
Wall time: 3 ms
```

. %time %timeit ! %timeit . , ( ) . %tiemit $time . %timeit %time % .

```
In [54]: %%time
         total = 0
         for i in range(1000):
             for j in range(1000):
                 total += i * (-1) ** j
```

```
Wall time: 534 ms
```

: %prun , . ( ) , IPython %prun . .

```
In [56]: def sum_of_lists(N):
             total = 0
             for i in range(5):
                 L = [j ^ (j>>i) for j in range(N)]
                 total += sum(L)
             return total
```

%prun .

```
In [57]: %prun sum_of_lists(100000)
```

(tottime) . , sum_of_lists . . IPython (IPython %prun?) %prun .

lprun %prun , . IPython line_profiler .

```
In [59]: %load_ext line_profiler
```

```
---------------------------------------------------------------------------
ModuleNotFoundError                       Traceback (most recent call last)

<ipython-input-59-df8a33df4eaf> in <module>()
----> 1 get_ipython().run_line_magic('load_ext', 'line_profiler')
      global get_ipython.run_line_magic = undefined

~\Anaconda3\lib\site-packages\IPython\core\interactiveshell.py in run_line_magic(self=<
```

```
   2129                 kwargs['local_ns'] = sys._getframe(stack_depth).f_locals
   2130             with self.builtin_trap:
-> 2131                 result = fn(*args,**kwargs)
        result = undefined
        fn = <bound method ExtensionMagics.load_ext of <IPython.core.magics.extension.Exte
        args = ['line_profiler']
        kwargs = {}
   2132             return result
   2133
```

```
    <decorator-gen-66> in load_ext(self=<IPython.core.magics.extension.ExtensionMagics obj
```

```
    ~\Anaconda3\lib\site-packages\IPython\core\magic.py in <lambda>(f=<function ExtensionMa
    185     # but it's overkill for just that one bit of state.
    186     def magic_deco(arg):
--> 187         call = lambda f, *a, **k: f(*a, **k)
        global call = undefined
        f = <function ExtensionMagics.load_ext at 0x000001E95B480048>
        a = (<IPython.core.magics.extension.ExtensionMagics object at 0x000001E95C2C6080>,
        k = {}
    188
    189         if callable(arg):
```

```
    ~\Anaconda3\lib\site-packages\IPython\core\magics\extension.py in load_ext(self=<IPytho
     31         if not module_str:
     32             raise UsageError('Missing module name.')
---> 33         res = self.shell.extension_manager.load_extension(module_str)
        res = undefined
        self.shell.extension_manager.load_extension = <bound method ExtensionManager.load_
        module_str = 'line_profiler'
     34
     35         if res == 'already loaded':
```

```
    ~\Anaconda3\lib\site-packages\IPython\core\extensions.py in load_extension(self=<IPytho
     83             if module_str not in sys.modules:
     84                 with prepended_to_syspath(self.ipython_extension_dir):
---> 85                     mod = import_module(module_str)
        mod = undefined
        global import_module = <function import_module at 0x000001E959F48E18>
        module_str = 'line_profiler'
     86                     if mod.__file__.startswith(self.ipython_extension_dir):
     87                         print(("Loading extensions from {dir} is deprecated. "
```

```
    ~\Anaconda3\lib\importlib\__init__.py in import_module(name='line_profiler', package=N
    125                 break
    126             level += 1
--> 127     return _bootstrap._gcd_import(name[level:], package, level)
        global _bootstrap._gcd_import = <function _gcd_import at 0x000001E959CFBE18>
        name = 'line_profiler'
        level = 0
        package = None
    128
    129


    ~\Anaconda3\lib\importlib\_bootstrap.py in _gcd_import(name='line_profiler', package=N


    ~\Anaconda3\lib\importlib\_bootstrap.py in _find_and_load(name='line_profiler', import


    ~\Anaconda3\lib\importlib\_bootstrap.py in _find_and_load_unlocked(name='line_profiler


    ModuleNotFoundError: No module named 'line_profiler'
```

1.8 : %memit %mprun

. IPython memory_profiler . line_profiler pip .

```
In [60]: %load_ext memory_profiler
```

. %memit %timeit , %mprun %lprun . %memit .

```
In [61]: %memit sum_of_lists(100000)
```

```
peak memory: 68.01 MiB, increment: 5.23 MiB
```

68MB . %mprun . %%file sum_of_lists mprun_demo.py . .

```
In [62]: %%file mprun_demo.py
         def sum_of_lists(N):
             total = 0
             for i in range(5):
                 L = [j ^ (j >> i) for j in range(N)]
                 total += sum(L)
                 del L
             return total
```

```
Writing mprun_demo.py
```