



Machine learning

Lesson 02. Basics of python

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Python in general

- What is python?
 - High level programming language
 - Emphasize on code readability
 - Very clear syntax + large and comprehensive standard library
 - Use of indentation for block delimiters
 - Multiprogramming paradigm: OO, imperative, functional, procedural, reflective
 - A fully [dynamic type](#) system and automatic [memory management](#)
 - Scripting language + standalone executable program + interpreter
 - Can run on many platform: Windows, Linux, Macintosh
- Updates:
 - Newest version: 3.2.2 (CPython, JPython, IronPython)
 - Website: www.python.org



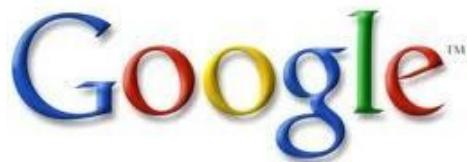
Python in general (Cont')

- Advantages:
 - Software quality
 - Developer productivity
 - Program portability
 - Support libraries
 - Component integration
 - Enjoyment
- Disadvantages:
 - not always be as fast as that of compiled languages such as C and C++



Python in general (Cont')

- Applications of python:



Python in general (Cont')

- Python's Capability:
 - System Programming
 - GUI
 - Internet Scripting
 - Component Integration
 - Database Programming
 - Rapid Prototyping
 - Numeric and Scientific Programming
 - Gaming, Images, Serial Ports, XML, Robots, and More



How Python program runs?

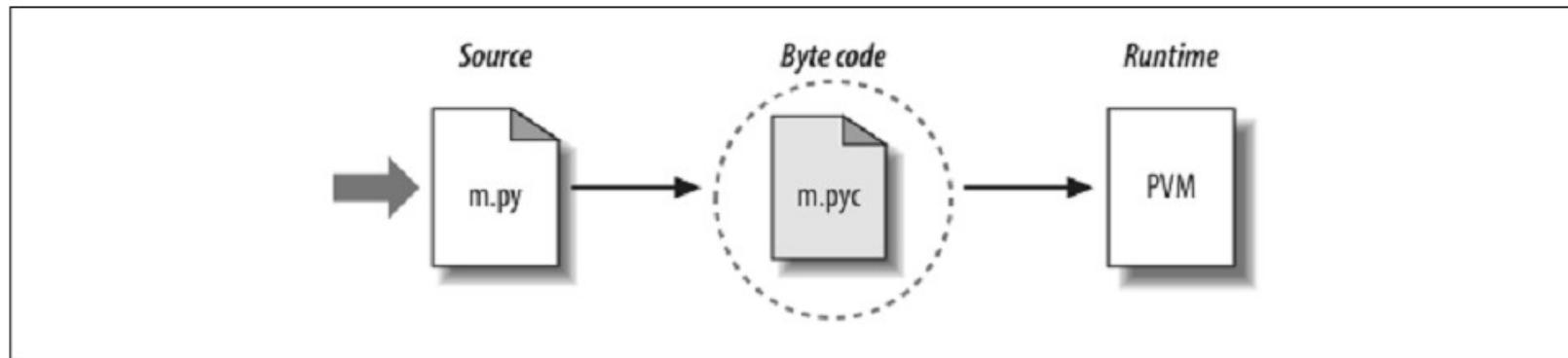


Figure 2-2. Python's traditional runtime execution model: source code you type is translated to byte code, which is then run by the Python Virtual Machine. Your code is automatically compiled, but then it is interpreted.

Notice: pure Python code runs at speeds somewhere between those of a traditional compiled language and a traditional interpreted language

HELLO WORLD

```
print "hello world"
```



FROM INTERPRETER

```
$ python  
->>> print "hello world"  
hello world
```



REPL

Read, Eval, Print, Loop



REPL

```
$ python
>>> 2 + 2 # read, eval
4          # print
>>>       # repeat (loop)
```



REPL (2)

Many developers keep a REPL handy
during programming



FROM SCRIPT

Make file `hello.py` with
`print "hello world"`

Run with:

`python hello.py`



(UNIX) SCRIPT

Make file `hello` with

```
#!/usr/bin/env python  
print "hello world"
```

Run with:

```
chmod +x hello  
../hello
```



PYTHON 3 HELLO WORLD

`print` is no longer a statement, but a function

```
print("hello world")
```



Objects



OBJECTS

Everything in *Python* is an object that has:

- an *identity* (`id`)
- a *value* (mutable or immutable)



id

```
>>> a = 4  
>>> id(a)  
6406896
```



VALUE

- **Mutable:** When you alter the item, the id is still the same. Dictionary, List
- **Immutable:** String, Integer, Tuple



MUTABLE

```
>>> b = []
>>> id(b)
140675605442000
>>> b.append(3)
>>> b
[3]
>>> id(b)
140675605442000    # SAME!
```



IMMUTABLE

```
>>> a = 4
>>> id(a)
6406896
>>> a = a + 1
>>> id(a)
6406872 # DIFFERENT!
```



VARIABLES

```
a = 4          # Integer
b = 5.6        # Float
c = "hello"    # String
a = "4"        # rebound to String
```



NAMING

- lowercase
- underscore_between_words
- don't start with numbers

See PEP 8



Math



MATH

`+, -, *, /, ** (power), % (modulo)`



CAREFUL WITH INTEGER DIVISION

```
>>> 3/4
```

```
0
```

```
>>> 3/4.
```

```
0.75
```

(In Python 3 // is integer division operator)



What happens when you
raise 10 to the 100th?



LONG

>>> 10**100

10000000000000000000000000000000
00000000000000000000000000000000
00000000000000000000000000000000
00000L



LONG(2)

```
>>> import sys  
>>> sys.maxint  
9223372036854775807  
>>> sys.maxint + 1  
9223372036854775808L
```



Strings



STRINGS

```
name = 'matt'  
with_quote = "I ain't gonna"  
longer = """This string has  
multiple lines  
in it"""
```



HOW DO I PRINT?

He said, “I’m sorry”



STRING ESCAPING

Escape with \

```
>>> print 'He said, "I\'m sorry"'  
He said, "I'm sorry"  
>>> print '''He said, "I'm sorry'''  
He said, "I'm sorry"  
>>> print """He said, "I'm sorry\"""  
He said, "I'm sorry"
```



STRING ESCAPING (2)

Escape Sequence	Output
\\"	Backslash
\'	Single quote
\\"	Double quote
\b	ASCII Backspace
\n	Newline
\t	Tab
\u12af	Unicode 16 bit
\U12af89bc	Unicode 32 bit
\o84	Octal character
\xFF	Hex character



STRING FORMATTING

c-like

```
>>> "%s %s" %('hello', 'world')
'hello world'
```

PEP 3101 style

```
>>> "{0} {1}".format('hello', 'world')
'hello world'
```



Methods & dir



dir

Lists attributes and methods:

```
>>> dir("a string")
['__add__', '__class__', ... 'startswith', 'strip',
'swapcase', 'title', 'translate', 'upper', 'zfill']
```



Whats with all the
'blah'?



DUNDER METHODS

dunder (double under) or "special/magic" methods determine what will happen when + (`__add__`) or / (`__div__`) is called.



help

```
>>> help("a string".startswith)
```

Help on built-in function startswith:

```
startswith(...)  
S.startswith(prefix[, start[, end]]) -> bool
```

Return True if S starts with the specified prefix, False otherwise.

With optional start, test S beginning at that position.

With optional end, stop comparing S at that position.

prefix can also be a tuple of strings to try.



STRING METHODS

- **s.endswith(sub)**

Returns True if endswith sub

- **s.find(sub)**

Returns index of sub or -1

- **s.format(*args)**

Places args in string



STRING METHODS (2)

- **s.index(sub)**

Returns index of `sub` or exception

- **s.join(list)**

Returns `list` items separated by string

- **s.strip()**

Removes whitespace from start/end



Comments



COMMENTS

Comments follow a #



COMMENTS

No multi-line comments



More Types



None

Pythonic way of saying NULL. Evaluates to False.

c = **None**



BOOLEANS

a = **True**

b = **False**



SEQUENCES

- *lists*
- *tuples*
- *sets*



LISTS

Hold sequences.

How would we find out the attributes & methods of a list?



LISTS

```
>>> dir([])  
['__add__', '__class__', '__contains__', ...  
'__iter__', ..., '__len__', ..., 'append', 'count',  
'extend', 'index', 'insert', 'pop', 'remove',  
'reverse', 'sort']
```



LISTS

```
>>> a = []
>>> a.append(4)
>>> a.append('hello')
>>> a.append(1)
>>> a.sort() # in place
>>> print a
[1, 4, 'hello']
```



LISTS

How would we find out documentation
for a method?



LISTS

help function:

```
>>> help([].append)
Help on built-in function append:

append(...)
L.append(object) -- append object to end
```



LIST METHODS

- **l.append(x)**

Insert x at end of list

- **l.extend(l2)**

Add l2 items to list

- **l.sort()**

In place sort



LIST METHODS (2)

- **l.reverse()**

Reverse list in place

- **l.remove(item)**

Remove first item found

- **l.pop()**

Remove/return item at end of list



Dictionaries



DICTIONARIES

Also called *hashmap* or *associative array* elsewhere

```
>>> age = {}  
>>> age['george'] = 10  
>>> age['fred'] = 12  
>>> age['henry'] = 10  
>>> print age['george']  
10
```



DICTIONARIES (2)

Find out if 'matt' in age

```
>>> 'matt' in age
```

```
False
```



in STATEMENT

Uses `__contains__` dunder method to determine membership. (Or `__iter__` as fallback)



.get

```
>>> print age['charles']
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'charles'
>>> print age.get('charles', 'Not found')
Not found
```



DELETING KEYS

Removing 'charles' from age

```
>>> del age['charles']
```



DELETING KEYS

`del` not in `dir.`. `pop` is an alternative



Functions



FUNCTIONS

```
def add_2(num):
    """return 2
    more than num
    """
    return num + 2

five = add_2(3)
```



FUNCTIONS (2)

- `def`
- function name
- (parameters)
- `:` + indent
- optional documentation
- body
- return



WHITE SPACE

Instead of { use a : and indent
consistently (4 spaces)



WHITESPACE (2)

invoke `python -tt` to error out during inconsistent tab/space usage in a file



DEFAULT (NAMED) PARAMETERS

```
def add_n(num, n=3):
    """default to
    adding 3"""
    return num + n
```

```
five = add_n(2)
ten = add_n(15, -5)
```



__doc__

Functions have *docstrings*. Accessible via `.__doc__` or `help`



__doc__

```
>>> def echo(txt):
...     "echo back txt"
...     return txt
>>> help(echo)
Help on function echo in module __main__:
<BLANKLINE>
echo(txt)
    echo back txt
<BLANKLINE>
```



NAMING

- lowercase
- underscore_between_words
- don't start with numbers
- verb

See PEP 8



Conditionals



CONDITIONALS

```
if grade > 90:  
    print "A"  
elif grade > 80:  
    print "B"  
elif grade > 70:  
    print "C"  
else:  
    print "D"
```



Remember the
colon/whitespace!



BOOLEANS

a = **True**

b = **False**



COMPARISON OPERATORS

Supports (`>`, `>=`, `<`, `<=`, `==`, `!=`)

```
>>> 5 > 9
```

```
False
```

```
>>> 'matt' != 'fred'
```

```
True
```

```
>>> isinstance('matt',  
               basestring)
```

```
True
```



BOOLEAN OPERATORS

and, or, not (for logical), &, |, and ^ (for bitwise)

```
>>> x = 5
```

```
>>> x < -4 or x > 4
```

```
True
```



BOOLEAN NOTE

Parens are only required for precedence

```
if (x > 10):  
    print "Big"
```

same as

```
if x > 10:  
    print "Big"
```



CHAINED COMPARISONS

```
if 3 < x < 5:  
    print "Four!"
```

Same as

```
if x > 3 and x < 5:  
    print "Four!"
```



Iteration



ITERATION

```
for number in [1,2,3,4,5,6]:  
    print number
```

```
for number in range(1, 7):  
    print number
```



range NOTE

Python tends to follow *half-open interval* (`[start, end)`) with `range` and slices.

- $\text{end} - \text{start} = \text{length}$
- easy to concat ranges w/o overlap



ITERATION (2)

Java/C-esque style of object in array
access (BAD):

```
animals = ["cat", "dog", "bird"]
for index in range(len(animals)):
    print index, animals[index]
```



ITERATION (3)

If you need indices, use `enumerate`

```
animals = ["cat", "dog", "bird"]
for index, value in enumerate(animals):
    print index, value
```



ITERATION (4)

Can break out of nearest loop

```
for item in sequence:  
    # process until first negative  
    if item < 0:  
        break  
    # process item
```



ITERATION (5)

Can continue to skip over items

```
for item in sequence:  
    if item < 0:  
        continue  
    # process all positive items
```



ITERATION (6)

Can loop over lists, strings, iterators, dictionaries... sequence like things:

```
my_dict = { "name": "matt", "cash": 5.45}
for key in my_dict.keys():
    # process key

for value in my_dict.values():
    # process value

for key, value in my_dict.items():
    # process items
```



pass

pass is a null operation

```
for i in range(10):
    # do nothing 10 times
    pass
```



HINT

Don't modify *list* or *dictionary* contents
while looping over them



Slicing



SLICING

Sequences (lists, tuples, strings, etc) can
be *sliced* to pull out a single item

```
my_pets = ["dog", "cat", "bird"]
favorite = my_pets[0]
bird = my_pets[-1]
```



NEGATIVE INDEXING

Proper way to think of [negative indexing] is to reinterpret $a[-X]$ as $a[\text{len}(a)-X]$

@gvanrossum



SLICING (2)

Slices can take an end index, to pull out a list of items

```
my_pets = ["dog", "cat", "bird"]
# a list
cat_and_dog = my_pets[0:2]
cat_and_dog2 = my_pets[:2]
cat_and_bird = my_pets[1:3]
cat_and_bird2 = my_pets[1:]
```



SLICING (3)

Slices can take a stride

```
my_pets = ["dog", "cat", "bird"]
# a list
dog_and_bird = [0:3:2]
zero_three_etc = range(0,10)
[::3]
```



SLICING (4)

Just to beat it in

```
veg = "tomatoe"  
correct = veg[:-1]  
tmte = veg[::2]  
eotamot = veg[::-1]
```



File IO



FILE INPUT

Open a file to read from it (old style):

```
fin = open("foo.txt")
for line in fin:
    # manipulate line
fin.close()
```



FILE OUTPUT

Open a file using '`w`' to write to a file:

```
fout = open("bar.txt", "w")
fout.write("hello world")
fout.close()
```



Always remember to
close your files!



CLOSING WITH `with`

implicit close (new 2.5+ style)

```
with open('bar.txt') as fin:  
    for line in fin:  
        # process line
```



Classes



CLASSES

```
class Animal(object):
    def __init__(self, name):
        self.name = name

    def talk(self):
        print "Generic Animal Sound"

animal = Animal("thing")
animal.talk()
```



CLASSES (2)

notes:

- `object` (base class) (fixed in 3.X)
- `dunder init` (constructor)
- all methods take `self` as first parameter



CLASSES(2)

Subclassing

```
class Cat(Animal):
    def talk(self):
        print '%s says, "Meow!"' % (self.name)

cat = Cat("Groucho")
cat.talk() # invoke method
```



CLASSES(3)

```
class Cheetah(Cat):
    """classes can have
    docstrings""""
```

```
def talk(self):
    print "Growl"
```



NAMING

- CamelCase
- don't start with numbers
- Nouns



Debugging



Poor Mans

`print` works a lot of the time



REMEMBER

Clean up `print` statements. If you really need them, use `logging` or write to `sys.stdout`



pdb

```
import pdb; pdb.set_trace()
```



pdb COMMANDS

- **h** - help
- **s** - step into
- **n** - next
- **c** - continue
- **w** - where am I (in stack)?
- **l** - list code around me

