

Python crash course

Machine Learning for Robotics

Máster Universitario en Ingeniería Industrial

Departamento de Automática

Objectives

1. Overview the Python syntax
2. Being able to program naïve Python scripts

Bibliography

The Python Tutorial

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Introduction

What is Python? (I)

Python is a general-purpose, high-level, interpreted programming language

- General-purpose: Many applications.
- High-level: Abstract data structures, doing more with less code.
- Interpreted: No need to compile.



It emphasizes code **readability** and programmer's productivity

Introduction

What is Python? (II)

Python

```
#!/usr/bin/python  
  
print("Hello , world !")
```

Java

```
public class HelloWorld {  
    public static void main( String []  
        args ) {  
        System.out.println( "Hello , world  
            !" );  
    }  
}
```

Hello world! examples

C

```
#include <stdio.h>  
  
int main()  
{  
    printf("Hello , world !\n");  
}
```

C++

```
#include <iostream>  
  
int main()  
{  
    std :: cout << "Hello , world !\n"  
        ;  
}
```

Introduction

History

- Python was created by Guido van Rossum in the Netherlands
- Python 2.0: Released on 2000
- Python 3.0: Released on 2008. Backwards-incompatible

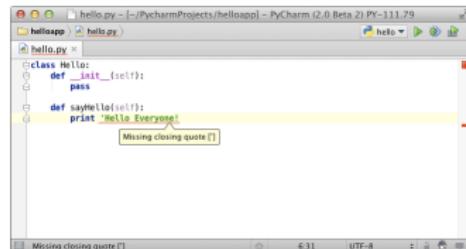
Python 3.X is the present but Python 2.x still popular



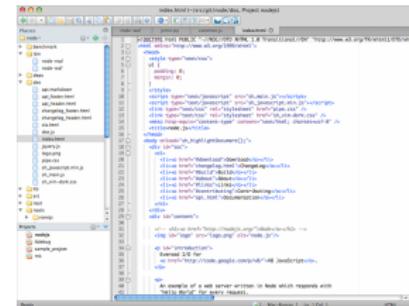
Introduction

Installation

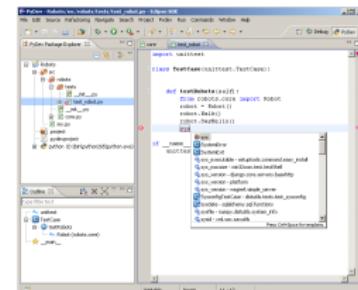
- If you have a good OS such as Linux or Mac, you already have Python!
 - Otherwise (Windows), you have to install it
 - Visit <https://www.python.org/downloads/>
 - Bad news: There is no “standard” IDE
 - PyCharm, Komodo, PyDev, ...
 - <http://wiki.python.org/moin/PythonEditors>
 - Notebooks are also very popular, particularly in AI



PyCharm



Komodo



PyDev

The Python interpreter

Python operation modes

Python is an interpreted language, i.e., it needs an interpreter.

- Interpreted = it is not complied = it needs no compilation.
- Faster development, slower execution.

Two operation modes:

- **Interactive:** The interpreter reads the program from the `stdin` (usually the keyboard).
- **Non-interactive:** The interpreter reads the program from a file (also known as `script`).

The Python interpreter

Interactive

Just run `python`

- Different names for different versions to avoid conflicts.
- `python`, `python3.4`, ...

```
localhost:~ user$ python3.4
Python 3.4.2 (v3.4.2:ab2co23a9432, Oct 5 2014, 20:42:22)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

The programmer executes as he writes code down.

The Python interpreter

Non-interactive

The program is in a plain text file.

- It can be edited with any text editor.
- Extension “.py”.
- Execution permission (`chmod u+x myscript.py`).
- By default, UTF-8 encoding.

The first line must be `#!/usr/bin/python`

- It is the interpreter location.
- If not present, the interpreted must be invoked.

script.py

```
#!/usr/bin/python  
  
print("Hello, world!")
```

```
python script.py  
./script.py
```

Variables

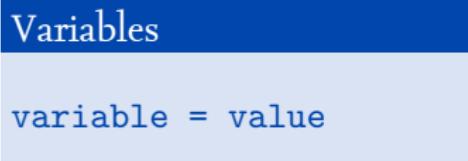
Numbers (I)

Variable: A name that refers a value.

- No need to declare variables (Python is weakly typed!).
- Python automatically assigns types.
- Basic types: Numbers, strings and booleans.

Complex data structures:

- Lists, tuples, dictionaries, associative arrays.



Variables

Numbers (II)

```
>> numberA = 4
>> numberB = 2.3
>> numberA + numberB
6.3
>> string = "Spam"
>> boolean = True
>> a = b = c = 0
>> b
0
>>> type(numberA)
<type 'int'>
```

```
a = int(input("Number: "))
b = float(input("Number: "))
c = (a * b) / 2
c += 1
d = c ** 2
print("Result c: ", c)
print("Result d: ", d)
```

New Python elements:

- The `input()` function.
- The `int()` and `float()` functions.
- The `type()` function.

An informal introduction

Strings (I)

Of course, variables can contain strings.

```
>>> text = "hello"  
>>> text = 'hello'  
>>> print(text)  
hello
```

Strings contatenation

```
>>> "hello" + " there"  
'hello there'  
>>> "hello" "there"  
'hellothere'
```

Variables with strings

```
>>> a = "hello"  
>>> b = " there"  
>>> a + b  
'hello there'
```

String length

```
>>> len("hello")  
5
```

An informal introduction

Strings (II)

F-strings: From Python 3.6

```
>>> name = 'John'  
>>> age = 22  
>>> print(f"Hi {name}, you are {age}")  
'Hi John, you are 22'
```

An informal introduction

Strings (III)

Strings are a sequence of characters: Slice notation.

- Quite common in Python data structures.
- It uses indices (as an array). First index is 0.

Slice notation

variable[start:stop:step]

```
>>> a = "hello"
>>> a[2]
'1'
>>> a[2:]
'illo'
>>> a[:2]
'he'
>>> a[2:] + a[:2]
'illohe'
>>> a[2:4]
'l1'
>>> a[::-2]
'hlo'
>>> a[::-1]
'olleh'
```

An informal introduction

Lists (I)

List: An ordered collection of mutable data.

- Very powerful data structure, similar to an array.
- Ordered: Data in the list have a location.
- Mutable: Data can be modified.
- Data types can be different.

List initialization

```
variable = [data1, data2, ..., dataN]
```

An informal introduction

Lists (II)

Initialization

```
>>> a = ['spam', 'eggs', 123]
['spam', 'eggs', 123]
```

Slice notation, `len()`
and + work on lists

```
>>> a[2]
123
>>> a[1:]
['eggs', 123]
>>> a + a
['spam', 'eggs', 123, 'spam', 'eggs', 123]
>>> len(a)
3
```

Data structures in Python

Lists (III)

Lists are objects: they have methods

- `list.append(x)`
- `list.insert(i, x)`
- `list.remove(x)`
- `list.pop()`
- `list.index(x)`
- `list.count(x)`
- `list.sort()`
- `list.reverse()`

```
>>> a = [66.25, 333, 333, 1, 1234.5]
>>> a.insert(2, -1)
>>> a.append(333)
>>> a
[66.25, 333, -1, 333, 1, 1234.5, 333]
>>> a.index(333)
1
>>> a.remove(333)
>>> a
[66.25, -1, 333, 1, 1234.5, 333]
>>> a.reverse()
>>> a
[333, 1234.5, 1, 333, -1, 66.25]
>>> a.sort()
>>> a
[-1, 1, 66.25, 333, 333, 1234.5]
```

Control flow

Conditions (I)

Conditional statements implement decision making

- Decide some code has to be executed or not.
- The result is a boolean.
- Execute code if condition is satisfied.

if statement

```
if <condition>:  
    # Some code  
else:  
    # Some other code
```

Example

```
if age > 18:  
    # Some code  
else:  
    # Some other code
```

New Python elements:

- Comments begin with '#'.
- Indentation plays a major role: It defines code bodies.

Control flow

Conditions (II)

Nested condition

```
if age == 18:  
    print("You are 18 years old")  
elif age < 18:  
    print("You are younger than 18 years old")  
elif age > 18:  
    print("You are older than 18 years old")  
else:  
    print("You should not be reading this")
```

Control flow

Conditions (III)

| SIGN | OPERATOR | SIGN | OPERATOR |
|------|------------------|------|-------------|
| == | Equal | and | Logical and |
| != | Not equal | or | Logical or |
| > | Greater | not | Logical not |
| < | Lower | | |
| >= | Greater or equal | | |
| <= | Lower or equal | | |

Nested condition

```
if (age > 18) and (name == "Biggus Dickus"):  
    print("Hi Biggus")
```

Control flow

for statements (I)

- Sometimes we have to repeat a task: Loops
 - Other languages iterate over a condition
 - For instance, in C: `for (i=0; i<10; i++)`
- Two loop statements in python: `while` and `for`
- In Python, `for` iterates over a sequence (lists or strings)
 - In each iteration, it assigns a sequence value to a variable

for statement example

```
for x in [ 'cat' , 'window' , 'dog' ]:  
    print(x)
```

for statement example

```
for x in "Hello word":  
    print(x)
```

Control flow

for statements (II)

Sometimes, we need to iterate over a sequence of numbers

- `range(n)`: It returns a sequence $0, \dots, n - 1$

range() example

```
for i in range(5):  
    print(i)
```

Alternative notation

```
a = [ 'Mary' , 'had' , 'a' ]  
  
for i in range(len(a)):  
    print(i, a[i])
```

Control flow

for statements (III)

List comprehensions are a concise way to create lists

- Widely used and convenient
- It does not return a list!

List with squares

```
squares = []
for x in range(10):
    squares.append(x**2)
```

Alternative notation

```
squares = [x**2 for x in range(10)]
```

List comprehensions support conditions

```
list = [x for x in range(10) if x%2 == 0]
```

Control flow

While loop

Fibonacci series

```
#!/usr/bin/python

a, b = 0, 1 # Init variables

while b < 10: # This is a loop
    print("b = ", b)
    print("a = ", a) # Indentation is very important here!
    a, b = b, a+b
```

New Python elements:

- Multiple assignments

Functions

Defining functions (I)

Function: A piece of code that can be used several times

- Lazy programmers are good programmers
- Code reuse

Functions can be used with parameters

- Define a function before using it

Function 1

```
def printHello():
    print("Hello")
printHello()
```

Function 2

```
def printTwice(string):
    print(string)
    print(string)

printTwice(string)
```

Hint: If you have to use code more than once, place it in a function

Functions

Defining functions (II)

A function can return a value with the keyword `return`

```
def computeSquare(x):
    """ Takes a number and returns its square """
    return x ** 2

computeSquare(3)
```

New Python feature:

- Docstrings

Functions

Default argument values and keyword arguments

Python supports default arguments:

- Powerful and simple feature.
- Simpler (and more flexible) function calls.

```
def sum(a, b=10):  
    return a + b  
  
sum(1, 2)  
sum(1)
```

Function arguments can be named:

- It overrides classic positional arguments.
- Positional arguments must be first.

```
def foo(bar, baz):  
    print(bar, baz)  
  
foo(1, 2)  
foo(baz = 2, bar = 1)
```

```
def foo(bar = "hello", baz = "bye"):  
    print(bar, baz)  
  
foo()  
foo("hi")  
foo(baz = "hi")
```

Data structures in Python

Tuples

Tuple: A sequence of items, very similar to lists.

- However they are not the same.
- Lists are mutable, tuples are immutable.
- Tuples used to contain, **usually**, heterogeneous items.
- Lists used to contain, **usually**, homogeneous items, used to iterate.

Tuple initialization

```
tuple = (item1, item2, ..., itemN)  
tuple = item1, item2, ..., itemN
```

Creation

```
tup1 = 1, 2, 3  
tup2 = ("Hi", 1.1, 2)  
tup3 = (0, (1, 3), 2)
```

Manipulation

```
>>> tup1[0]  
1  
>>> tup1  
(1, 2, 3)  
>>> tup1[1:]  
(2, 3)
```

Data structures in Python

Sets

Set: A collection of items, unordered with no duplicates.

- Membership testing.
- Eliminating duplicate entries.

Set initialization

```
set = item1, item2, ..., itemN
```

Creation

```
>>> set1 = {"red", "blue"}  
>>> set_mix = set(['a', True, 33])  
>>> set_mix  
{'a', True, 33}  
>>> len(set_mix)  
3  
>>> 33 in set1  
True
```

Sequence: All types that behaves like sequences: Strings, lists and tuples.

Data structures in Python

Dictionaries (I)

Dictionary: A collection of pairs <key, value>

- Also named as *associative array*, very similar to hash maps.
- Lists are indexed with a number, dictionaries use keys.
- Key: Numbers, strings, tuples and any immutable type.

Dictionary initialization

```
dict = {key1: value1, key2: value2}
```

Creation

```
>>> tel = { 'jack' : 4098, 'sape' : 4139 }
```

Manipulation

```
>>> tel[ 'guido' ] = 4127
>>> del tel[ 'sape' ]
>>> tel
{ 'guido': 4127, 'jack': 4098}
>>> list(tel.keys())
[ 'guido', 'jack' ]
>>> 'guido' in tel
True
```

Data structures in Python

Dictionaries (II)

Dictionaries can be iterated by key or by value

- Loop syntax is slightly different
- `item()` method

Dictionary iteration

```
knights = { 'gallard' : 'the pure', 'robin' : 'the brave' }

for k, v in knights.items():
    print(k, v)

for k in knights.keys():
    print(k)
```

Data structures in Python

Summary

| DATA STRUCTURE | INITIALIZATION |
|----------------|--|
| List | <code>li = [1, 2, 3]</code> |
| Tuple | <code>tu = (1, 2, 3)</code> <code>tu = 1, 2, 3</code> |
| Set | <code>se = {1, 2, 3}</code> |
| Dictionary | <code>dic = {'abc' : 1, 'bca' : 2}</code> |

Modules

Introduction (I)

You loose everything when exit the interpreter

- Solution: Write it down in a script

When a script becomes big, it is difficult to maintain

- Solution: Split your script in several ones

As you get more scripts, you will need to reuse your functions

- Solution: Create a **module**
- **Module:** A file that contains definitions, functions and classes

If a module is too big, it is too difficult to maintain

- Solution: Create a **package**
- **Package:** A module of modules

Modules

Installing packages

Command-line automatic tool: pip

- Very similar to apt-get in Linux

pip usage

```
$ python -m pip install SomePackage
```

pip alternative usage

```
$ pip3 install SomePackage
```

Example of the PIL installation:

```
$ pip3 install Pillow
```

(More info)

Modules

Namespaces (I)

Importing packages

```
import <package> [as <name>]
```

A module can import other modules

- Name conflicts may arise: Each module has a symbol table
- It means you should invoke it as `modname.itemname`
- The module name can be changed with the keyword `as`

```
>>> import math  
>>> math.log(10)  
2.302585092994046
```

```
>>> import math as m  
>>> m.log(10)  
2.302585092994046
```

Modules

Namespaces (II)

It is possible to import items directly

- `from module import name1, name2`
- `from module import *`
- It uses the global symbol table (no need to use the modname)

```
>>> from math import log
>>> log(10)
2.302585092994046
```

```
>>> from math import *
>>> log(10)
2.302585092994046
```

Modules

Example 1: Open a web browser

browser.py

```
import webbrowser

webbrowser.open("https://www.reddit.com")
```

also

browser2.py

```
import webbrowser as w

w.open("https://www.reddit.com")
```

Modules

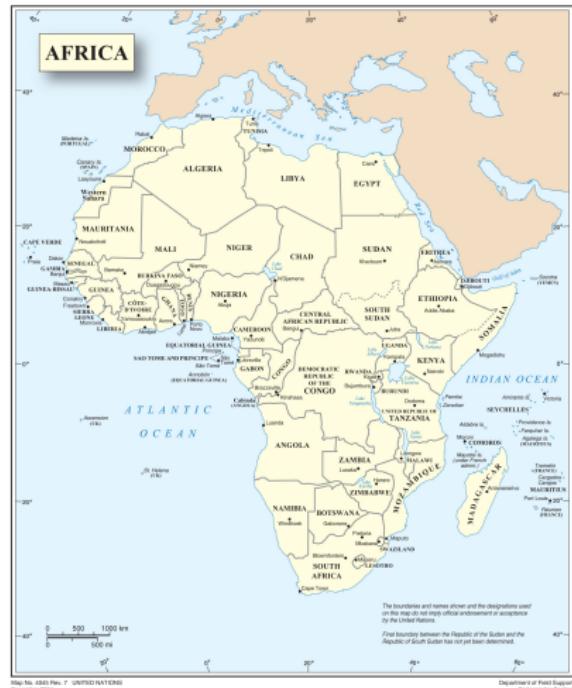
Example 2: Create a thumbnail

thumbnail.py

```
from PIL import Image

size = (128, 128)

im = Image.open("africa.tif")
im.thumbnail(size)
im.save("africa.jpg")
im.show()
```



(Source)

africa.jpg

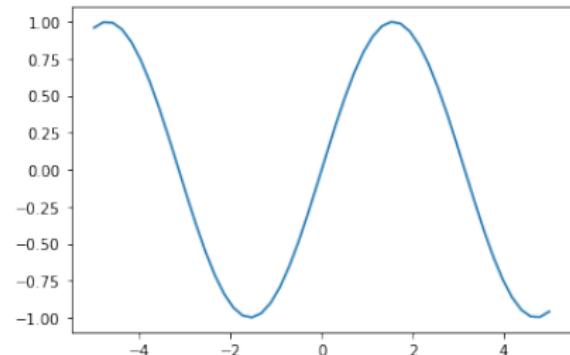
Modules

Example 3: Plot

plot.py

```
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(-5, 5)
plt.plot(x, np.sin(x))
```



Classes in Python (I)

- **Class:** Start with the word `class` followed by class name written in **capital letter** and a colon [Substantives].
- **Attributes:** A lowercase noun.
 - There is no need to declare attributes.
- **Inherited class:** Similar to a class but the class name followed by the class father in brackets.
- **Instance:** Object in lower case followed by the class assignment.

coche.py

```
class Vehiculo:  
    def __init__(self, ruedas):  
        self.ruedas = ruedas  
  
class Coche(Vehiculo):  
    def __init__(self, ruedas, modelo):  
        Vehiculo.__init__(self, ruedas)  
        self.modelo = modelo  
  
ford = Coche(4, "mondeo")
```

Classes in Python (II)

- **Method:** Start with the word `def`

- Methods receive automatically a reference to the object (usually named `self`).

- **Constructor:** Method whose name is `__init__()`, the first attribute is `self`.
- All methods and attributes are public.

- By convention, private members begin with double underscore (`__varName`,
`__method_name()`)

Classes in Python (III)

Two operations on classes

Instantiation

Creates a new object

Standard functional notation

```
x = MyClass()
```

Example

```
time = Time()
```

Attribute references

Accesses an attribute value

Standard dot syntax

```
obj.name
```

Example

```
time.hour = 4
print(time.hour)
hour = time.hour
```