Python crash course

Inteligencia Artificial en los Sistemas de Control Autónomo
Máster en Ciencia y Tecnología desde el Espacio

Departamento de Automática

Universidad de Alcalá

ISG

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 **readibility** and programmer's productivity

Introduction

What is Python? (II)

Hello world! examples

Python

```
#!/usr/bin/python

print("Hello, world!")
```

Java

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

C

```
#include <stdio.h>

int main()
{
  printf("Hello, world!\n");
}
```

C++

```
#include <iostream>

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

Introduction

History

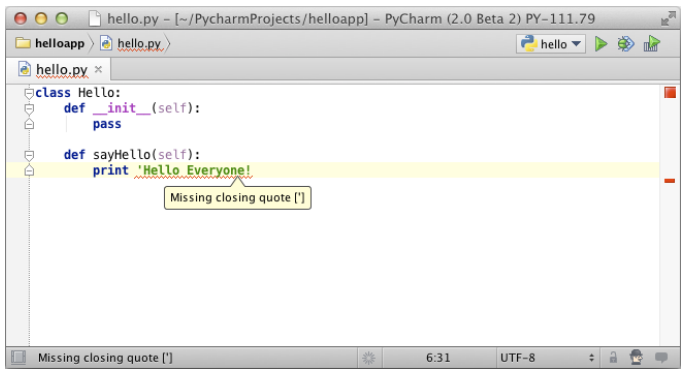
- Python was created by Guido van Rossum in the Netherlands
- Python 2.0: Released on 2000
- Python 3.0: Released on 2008. Backwards-incompatible

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

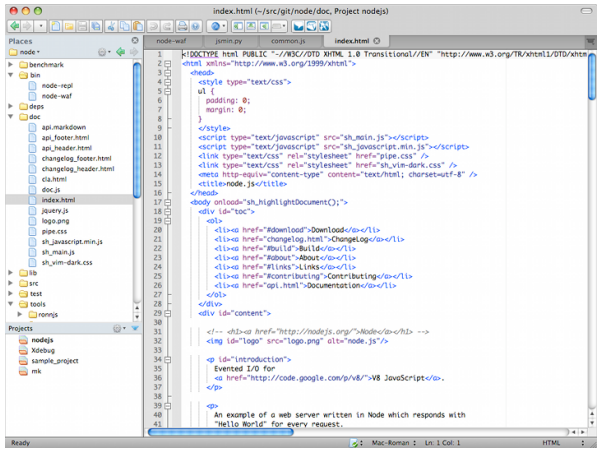
Introduction

Installation

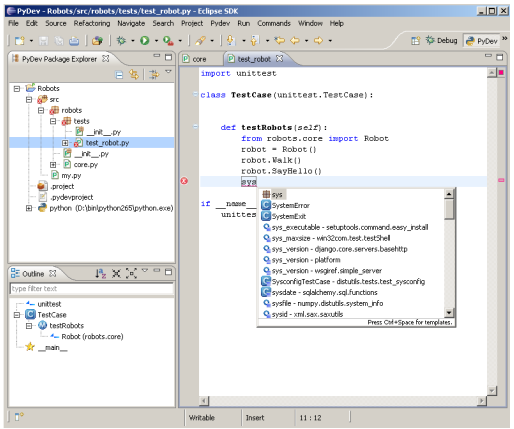
- If you have a good OS such as Linux or Mac, you already have Python!
- Otherwise (Windows), you have to install it
  - Visit `https://www.python.org/downloads/`
- Bad news: There is no "standard" IDE
  - PyCharm, Komodo, PyDev, ...
  - `http://wiki.python.org/moin/PythonEditors`
  - *Notebooks* are 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:ab2c023a9432, 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

```
variable = value
```

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]
'l'
>>> a[2:]
'llo'
>>> a[:2]
'he'
>>> a[2:] + a[:2]
'llohe'
>>> a[2:4]
'll'
>>> 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 mayor 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 $0, ..., n-1$

`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])
```

Iterate over a sequence of numbers with indices

- `enumerate(list)`

`enumerate()` example

```
for i, value in enumerate(['a', 'b', 'c']):
    print(f"index: {i}, value: {value}")
```

Control flow

`for` statements (III)

List comprehensions are a concise way to create lists

- Widely used and convenient

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)  # Identation 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("hello")
```

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 keywork return

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

x2= computeSquare(3)
print(f"x2 = {x2}")
```

New Python feature:

- Docstrings

Functions

Default argument values and keyword arguments

Python supports default arguments:

- Poweful 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: Ordered sequence of items, very similar to lists.

- However they are not the same.
- Lists are *mutable*, tuples are *inmutable*.
- Tuples use to contain, **usually**, heterogeneus items.
- Lists use to contain, **usually**, homogeneus 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 inmutable 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
- `items()` 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	`li = [1, 2, 3]`
Tuple	`tu = (1, 2, 3)`
	`tu = 1, 2, 3`
Set	`se = {1, 2, 3}`
Dictionary	`dic = {'abc' : 1, 'bca' : 2}`

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

Introduction (II)

Lots of packages for space!!!

(AstroPy)

(SunPy)

(SpacePy)

(AstroML)

(Poliastro)

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 keywork *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

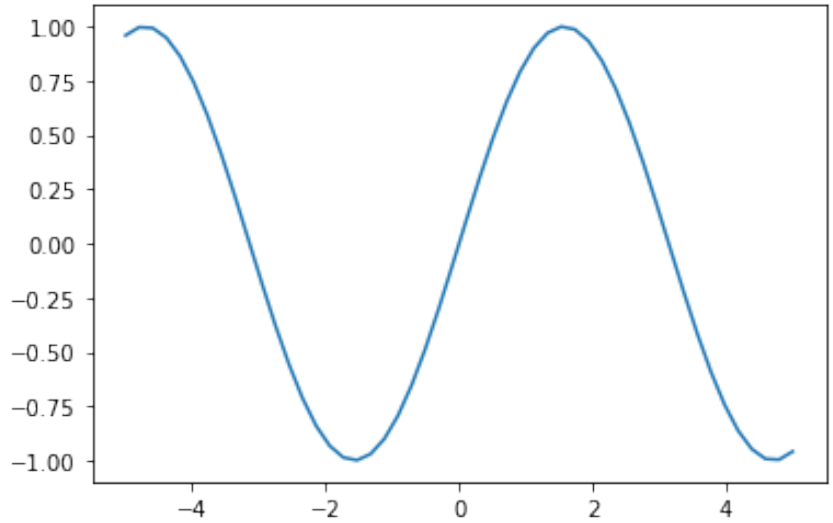
Modules

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.

car.py

```
class Vehicle:
  def __init__(self, wheels):
    self.wheels = wheels

class Car(Vehicle):
  def __init__(self, wheels, model):
    Vehicle.__init__(self, wheels)
    self.model = model

ford = Car(4, "mondeo")
myBike = Car(2)
```

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
```