

Une pas si courte introduction au langage de programmation Python comme alternative à Matlab pour réaliser des calculs scientifiques ou d'autres applications.

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February 3, 2015

Introduction

Description du Langage

Description des paquets scientifiques

Distributions et Environnements de travail

Conclusion

Outline

Introduction

Description du Langage

Description des paquets scientifiques

Distributions et Environnements de travail

Conclusion

Historique

Python

- ▶ 1989–1995 : Hollande
- ▶ 1995–1999 : USA
- ▶ 1999+ : Worldwide open source

sources : <http://www.wikipedia.org>, <http://www.python.org>

Historique

Python

- ▶ 1989–1995 : Hollande
 - ▶ Centrum voor Wiskunde en Informatica (CWI).
 - ▶ *Guido von Rossum*, fan des Monty Python, travaille sur :
 - ▶ ABC : langage de script, syntaxe et indentation.
 - ▶ Modula-3 : gestion des exceptions, orienté objet.
 - ▶ langage C, Unix.
 - ▶ OS distribué Amoeba: accès difficile en shell.
 - ▶ Crée le langage Python :
 - ▶ 1991/02 : versions 0.9.06 déposée sur un newsgroup de Usenet
 - ▶ 1995 : dépôt de la version 1.2
- ▶ 1995–1999 : USA
- ▶ 1999+ : Worldwide open source



Historique

Python

- ▶ 1989–1995 : Hollande
- ▶ 1995–1999 : USA
 - ▶ Corporation for National Research Initiatives (CNRI), non profit organisation, Reston, USA.
 - ▶ Grail7 : navigateur internet utilisant Tk.
 - ▶ 1999 : projet *Computer Programming for Everybody* (CP4E) (CNRI, DARPA Defense Advanced Research Projects Agency) :
 - ▶ Python comme langage d'enseignement de la programmation.
 - ▶ Crédit de l'IDLE (Integrated DeveLopment Environment)
 - ▶ 1999 : Python 1.6
 - ▶ 1999+ : Worldwide open source



Historique

Python

- ▶ 1989–1995 : Hollande
- ▶ 1995–1999 : USA
- ▶ 1999+ : Worldwide open source
 - ▶ BeOpen.com :
 - ▶ compatibilité GPL (General Public Licence)
 - ▶ création de la branche pythonLabs
 - ▶ 2000 : Python Software Foundation
 - ▶ Python 2.1 : changement licence, dérivée de Apache Software Foundation (OO, svn, commons plutôt java)
(<http://www.apache.org>).
 - ▶ 2008: Python 3.0



sources : <http://www.wikipedia.org>, <http://www.python.org>

Historique

Guido van Rossum

- ▶ Guido van Rossum :
 - ▶ 31 janvier 1956 (59 ans)
 - ▶ Développeur néerlandais
 - ▶ 1982 : M. Sc
 - ▶ Développeur ABC.
- ▶ Créeur Python : *Benevolent Dictator For Life (BDFL)*
 - ▶ 1991 : Python 0.9.06
 - ▶ 1999 : Grail
- ▶ 2002 : Prix pour le développement du logiciel libre 2001 décerné par la *Free Software Foundation*
- ▶ 2005–2012 : Google (python)
- ▶ 2013 : Dropbox



2006, source wikipedia

sources : <http://www.wikipedia.org>, <http://www.python.org>

Spécificités

<http://www.python.org/about/>

- ▶ Fortement typé.
- ▶ Objet.
- ▶ Script, séquentiel, interprété : fichier génère du byte code.
- ▶ Comparé à Tcl, Perl, Ruby, Scheme, Java.

Spécificités

Exemple 1er programme

Dans le fichier "hello.py" :

```
print("Bonjour monde")
```

Exécution dans une interface système (terminal, shell) :

```
~/python/example> python hello.py  
Bonjour monde
```

Spécificités

Exemple shell scripting

Exemple copies des fichiers '.txt' et '.tex' du répertoire 'a' vers 'b'.

```
# -*- encode: utf-8 -*-
import shutil, os
extList = ['.txt', '.tex']
pathSrc = 'a'
pathDst = 'b'
fileList = os.listdir(pathSrc)
for fileSrc in fileList:
    if (os.path.splitext(fileSrc)[1] in extList):
        fullfileSrc = os.path.join(pathSrc, os.path.basename(fileSrc))
        fullfileDst = os.path.join(pathDst, os.path.basename(fileSrc))
        shutil.move(fullfileSrc, fullfileDst)
```

Utilisations

A partir du shell

- ▶ Fichiers "*.py" contient des scripts et des définitions de fonctions. Ils sont exécutés dans le shell avec la commande "python".
Exemple : "python hello.py"
- ▶ La commande "python" ouvre une console utilisateur (*interpreter*) avec une invite de commande (prompt) caractéristique "> > >"

```
Enthought Canopy Python 2.7.3 | 64-bit | (default, Jun 14 2013, 18:17:36)
[GCC 4.2.1 (Apple Inc. build 5666) (dot 3)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

Utilisations

Utilisation de l'interpréteur

- ▶ Association d'une valeur à une variable : `a = 'abc'`
- ▶ Affichage de la valeur : `print()`
- ▶ Liste des noms, attributs, fonctions disponibles : `dir()`

```
>>> a = "abc"
>>> print(a)
abc
>>> dir()
['__builtins__', '__doc__', '__name__', '__package__', 'a']

>>> dir(a)
['__add__', '__class__', '__contains__', '__delattr__', '__doc__',
 '__eq__', '__format__', '__ge__', '__getattribute__', '__getitem__',
 '__getnewargs__', '__getslice__', '__gt__', '__hash__', '__init__',
 '__le__', '__len__', '__lt__', '__mod__', '__mul__', '__ne__', '__new__',
 '__reduce__', '__reduce_ex__', '__repr__', '__rmod__', '__rmul__',
 '__setattr__', '__sizeof__', '__str__', '__subclasshook__',
 '__formatter_field_name_split__', '__formatter_parser__', 'capitalize',
 'center', 'count', 'decode', 'encode', 'endswith', 'expandtabs', 'find',
 'format', 'index', 'isalnum', 'isalpha', 'isdigit', 'islower', 'isspace',
 'istitle', 'isupper', 'join', 'ljust', 'lower', 'lstrip', 'partition',
 'replace', 'rfind', 'rindex', 'rjust', 'rpartition', 'rsplit', 'rstrip',
 'split', 'splitlines', 'startswith', 'strip', 'swapcase', 'title',
 'translate', 'upper', 'zfill']
```

Utilisations

Utilisation de l'interpréteur

- ▶ Besoin d'aide : help()

```
>>> help(a.find)

Help on built-in function find:

find(...)
    S.find(sub [,start [,end]]) -> int

    Return the lowest index in S where substring sub is found,
    such that sub is contained within S[start:end].  Optional
    arguments start and end are interpreted as in slice notation.

    Return -1 on failure.
(END)
```

Site Web

www.python.org

The screenshot shows the Python Software Foundation website at www.python.org. The page features a dark blue header with the Python logo and the word "python" in white. A navigation bar above the main content includes links for Python, PSF, Docs, PyPI, Jobs, and Community. Below the header is a search bar with a magnifying glass icon and a "GO" button. To the right of the search bar are links for Socialize and Sign In. The main content area has a dark blue background. On the left, there is a code editor window showing a Python script. The script prints "Hello, I'm Python!" and then asks for a name, printing "Hi, %s" followed by the user's input. On the right, a section titled "Quick & Easy to Learn" discusses Python's readability and ease of learning, with a link to "Whet your appetite". Below this section are five numbered buttons (1, 2, 3, 4, 5). At the bottom of the main content area, a call-to-action reads: "Python is a programming language that lets you work quickly and integrate systems more effectively. [»» Learn More](#)". The footer contains four sections: "Get Started", "Download", "Docs", and "Jobs", each with a brief description and a corresponding icon.

Welcome to Python.org

Python Software Foundation www.python.org

Python PSF Docs PyPI Jobs Community

python™

Search GO Socialize Sign In

About Downloads Documentation Community Success Stories News Events

```
# Python 3: Simple output (with Unicode)
>>> print("Hello, I'm Python!")
Hello, I'm Python!

# Input, assignment
>>> name = input('What is your name?\n')
>>> print('Hi, %s.' % name)
What is your name?
Python
Hi, Python.
```

Quick & Easy to Learn

Experienced programmers in any other language can pick up Python very quickly, and beginners find the clean syntax and indentation structure easy to learn. [Whet your appetite](#) with our Python 3 overview.

1 2 3 4 5

Python is a programming language that lets you work quickly and integrate systems more effectively. [»» Learn More](#)

Get Started

Whether you're new to programming or an experienced developer, it's easy to learn and use Python.

Download

Python source code and installers are available for download for all versions! Not sure which version to use? [Check here.](#)

Docs

Documentation for Python's standard library, along with tutorials and guides, are available online.

Jobs

Looking for work or have a Python related position that you're trying to hire for? Our community-run job board is the place to go.



Documentation

Trouver la documentation

The screenshot shows a web browser displaying the Python 2.7.9 documentation. The title bar reads "Python Software Foundation docs.python.org/2/". The main content area is titled "Python 2.7.9 documentation". It features a sidebar on the left with links for "Download", "Docs for other versions" (listing Python 3.4, 3.5, and Old versions), and "Other resources" (PEP Index, Beginner's Guide, Book List, Audio/Visual Talks). A "Quick search" input field is also present. The main content area includes sections for "Welcome!", "Parts of the documentation:", "What's new in Python 2.7?", "Tutorial", "Library Reference", "Language Reference", "Python Setup and Usage", "Python HOWTOs", "Extending and Embedding", "Python/C API", "Installing Python Modules", "Distributing Python Modules", "FAQs", and "Indices and tables:". Each section has a brief description below it. At the bottom right, there are navigation icons for back, forward, and search.

Python » 2.7.9 Documentation » modules | index

Python 2.7.9 documentation

Welcome! This is the documentation for Python 2.7.9, last updated Jan 13, 2015.

Parts of the documentation:

What's new in Python 2.7?
or all "What's new" documents since 2.0

Tutorial
start here

Library Reference
keep this under your pillow

Language Reference
describes syntax and language elements

Python Setup and Usage
how to use Python on different platforms

Python HOWTOs
in-depth documents on specific topics

Extending and Embedding
tutorial for C/C++ programmers

Python/C API
reference for C/C++ programmers

Installing Python Modules
information for installers & sys-admins

Distributing Python Modules
sharing modules with others

FAQs
frequently asked questions (with answers!)

Indices and tables:

Global Module Index
quick access to all modules

General Index
all functions, classes, terms

Glossary
the most important terms explained

Search page
search this documentation

Complete Table of Contents
lists all sections and subsections

Documentation

Lire la documentation - Tutorial

The screenshot shows a PDF viewer window titled "tutorial.pdf". The left panel displays a table of contents for the Python Tutorial, while the right panel shows the first page of the tutorial.

Table of Contents:

- ▶ Whetting Your Appetite
- ▶ Using the Python Interpreter
- ▶ An Informal Introduction to Python
- ▶ More Control Flow Tools
- ▶ Data Structures
- ▶ Modules
- ▶ Input and Output
- ▶ Errors and Exceptions
- ▶ Classes
- ▶ Brief Tour of the Standard Library
- ▶ Brief Tour of the Standard Library – Part II
- ▶ What Now?
- ▶ Interactive Input Editing and History Substitution
- ▶ Floating Point Arithmetic: Issues and Limitations
- ▶ Glossary
- ▶ About these documents
- ▶ History and License
- ▶ Copyright
- ▶ Index

Page Content:

Python Tutorial
Release 2.7.3

Guido van Rossum
Fred L. Drake, Jr., editor

June 11, 2012

Documentation

Lire la documentation - Library reference

The screenshot shows a PDF viewer window titled "library.pdf". The left sidebar contains a table of contents for "Signets" under "Built-in Types", listing various built-in types like Integers, Floating Point Numbers, and Sequences. The main content area displays a table of bitwise operations:

Operation	Result	Notes
<code>x y</code>	bitwise or of <code>x</code> and <code>y</code>	
<code>x ^ y</code>	bitwise exclusive or of <code>x</code> and <code>y</code>	
<code>x & y</code>	bitwise and of <code>x</code> and <code>y</code>	
<code>x << n</code>	<code>x</code> shifted left by <code>n</code> bits	(1)(2)
<code>x >> n</code>	<code>x</code> shifted right by <code>n</code> bits	(1)(3)
<code>-x</code>	the bits of <code>x</code> inverted	

Below the table, notes explain the shift counts and their equivalents:

1. Negative shift counts are illegal and cause a `ValueError` to be raised.
2. A left shift by `n` bits is equivalent to multiplication by `pow(2, n)`. A long integer is returned if the result exceeds the range of plain integers.
3. A right shift by `n` bits is equivalent to division by `pow(2, -n)`.

5.4.2 Additional Methods on Integer Types

The integer types implement the `numbers.Integral` abstract base class. In addition, they provide one more method:

```
int.bit_length()  
long.bit_length()  
    Return the number of bits necessary to represent an integer in binary, excluding the sign and leading zeros:
```

```
>>> n = -37  
>>> bin(n)  
'-0b100101'  
>>> n.bit_length()  
6
```

More precisely, if `x` is nonzero, then `x.bit_length()` is the unique positive integer `k` such that $2^{k-1} \leq |x| < 2^k$. Equivalently, when `abs(x)` is small enough to have a correctly rounded logarithm, then $k = 1 + \text{int}(\log(\text{abs}(x), 2))$. If `x` is zero, then `x.bit_length()` returns 0.

Equivalent to:

Documentation

Lire la documentation - Library reference

The Python Library Reference, Release 2.7.3

os.listdir(path)
Return a list containing the names of the entries in the directory given by *path*. The list is in arbitrary order. It does not include the special entries '.' and '..' even if they are present in the directory.

Availability: Unix, Windows. Changed in version 2.3: On Windows NT/2k/XP and Unix, if *path* is a Unicode object, the result will be a list of Unicode objects. Undecodable filenames will still be returned as string objects.

os.lstat(path)
Perform the equivalent of an `lstat()` system call on the given path. Similar to `stat()`, but does not follow symbolic links. On platforms that do not support symbolic links, this is an alias for `stat()`.

os.mkfifo(path[, mode])
Create a FIFO (a named pipe) named *path* with numeric mode *mode*. The default mode is 0666 (octal). The current umask value is first masked out from the mode.

Availability: Unix.

FIFOs are pipes that can be accessed like regular files. FIFOs exist until they are deleted (for example with `os.unlink()`). Generally, FIFOs are used as rendezvous between "client" and "server" type processes: the server opens the FIFO for reading, and the client opens it for writing. Note that `mkfifo()` doesn't open the FIFO—it just creates the rendezvous point.

os.mknod(filename[, mode=0600[, device=0]])
Create a filesystem node (file, device special file or named pipe) named *filename*. *mode* specifies both the permissions to use and the type of node to be created, being combined (bitwise OR) with one of `stat.S_IFREG`, `stat.S_IFCHR`, `stat.S_IFBLK`, and `stat.S_IFIFO` (those constants are available in `stat`). For `stat.S_IFCHR` and `stat.S_IFBLK`, *device* defines the newly created device special file (probably using `os.makedev()`), otherwise it is ignored. New in version 2.3.

os.major(device)
Extract the device major number from a raw device number (usually the `st_dev` or `st_rdev` field from `stat`). New in version 2.3.

os.minor(device)
Extract the device minor number from a raw device number (usually the `st_dev` or `st_rdev` field from `stat`). New in version 2.3.

os.makedev(major, minor)
Compose a raw device number from the major and minor device numbers. New in version 2.3.

os.mkdir(path[, mode])

Documentation

Lire la documentation - Language reference

The screenshot shows a PDF viewer window displaying the "reference.pdf" file. The left sidebar contains a table of contents with sections like Introduction, Lexical analysis, Identifiers and keywords, Data model, Execution model, Expressions, Simple statements, Compound statements, Top-level components, Full Grammar specification, Glossary, About these documents, History and License, Copyright, and Index. The main content area is titled "2.3 Identifiers and keywords". It defines identifiers as sequences of letters, digits, and underscores, starting with a letter. It lists lowercase and uppercase letters, digits, and underscores as valid characters. It notes that identifiers are unlimited in length and case is significant. A section on "Keywords" follows, listing reserved words like and, del, from, not, while, as, elif, global, or, with, assert, else, if, pass, yield, break, except, import, print, class, exec, in, raise, continue, finally, is, return, def, for, lambda, and try. A note states that "None" became a constant in version 2.4. Another note says "as" and "with" became full keywords in version 2.6. The "2.3.2 Reserved classes of identifiers" section is also visible at the bottom.

2.3 Identifiers and keywords

Identifiers (also referred to as *names*) are described by the following lexical definitions:

```
identifier ::= (letter|"_") (letter | digit | "_")*
letter ::= lowercase | uppercase
lowercase ::= "a"..."z"
uppercase ::= "A"..."Z"
digit ::= "0"..."9"
```

Identifiers are unlimited in length. Case is significant.

2.3.1 Keywords

The following identifiers are used as reserved words, or *keywords* of the language, and cannot be used as ordinary identifiers. They must be spelled exactly as written here:

```
and      del      from      not      while
as       elif     global     or       with
assert   else     if        pass     yield
break   except   import    print
class    exec    in        raise
continue finally  is       return
def     for     lambda   try
```

Changed in version 2.4: `None` became a constant and is now recognized by the compiler as a name for the built-in object `None`. Although it is not a keyword, you cannot assign a different object to it. Changed in version 2.5: Using `as` and `with` as identifiers triggers a warning. To use them as keywords, enable the `with_statement` future feature. Changed in version 2.6: `as` and `with` are full keywords.

2.3.2 Reserved classes of identifiers

Certain classes of identifiers (besides keywords) have special meanings. These classes are identified by the patterns of leading and trailing underscore characters:

- Not imported by `from module import *`. The special identifier `_` is used in the interactive interpreter to store the result of the last evaluation; it is stored in the `__builtin__` module. When not in interactive mode, `_` has no special meaning and is not defined. See section *The import statement*.

Python Enhancements Proposals

PEPs

Propositions et conseils pour l'utilisation et l'amélioration du langage.

The screenshot shows a web browser window displaying the Python Software Foundation's PEP index page at www.python.org/dev/peps/. The page title is "PEP 0 -- Index of Python Enhancement Proposals (PEPs)".

Recent Activity:

- PEP 0: Python Events Calendars - Please submit your 2015 events (18 Dec)
- PEP 1: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 2: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 3: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 4: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 5: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 6: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 7: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)
- PEP 8: Python Software Foundation Core坦率地 announced for #ics2015 (18 Dec)

Introduction:

This PEP contains the index of all Python Enhancement Proposals, known as PEPs. PEP numbers are assigned by the PEP editors, and once assigned are never changed[1]. The Mercurial history[2] of the PEP texts represent their historical record.

Index by Category:

num	title	owner
---	-----	-----

Meta-PEPs (PEPs about PEPs or Processes):

P	1 PEP Purpose and Guidelines	Warsaw, Hylton,
	Goodger, Coghlan	
P	4 Deprecation of Standard Modules	von Löwis
P	5 Guidelines for Language Evolution	Prescod
P	6 Bug Fix Releases	Aahz, Baxter
P	7 Style Guide for C Code	GvR
P	8 Style Guide for Python Code	GvR, Warsaw,

Navigation icons: back, forward, search, etc.

Installation

- ▶ Téléchargement sous www.python.org pour les OS courants : Windows, Linux, Mac.
- ▶ 32 bits vs 64 bits :
 - ▶ Performances vs compatibilités bibliothèques (paquets)
 - ▶ Problèmes de configuration des compilateurs (gcc).
 - ▶ Actuellement, peut générer des problèmes.
- ▶ Autres distributions : Enthought Canopy, pythonXY, WinPython, ...
- ▶ Implémentations alternatives :
 - ▶ Langage identique mais implémentation différentes permet par exemple : d'interfacer du java facilement (Jython), d'être plus performant pour les calculs avec un compilateur JIT (Pypy)...

Installation

Python 2.7 vs 3.x

- ▶ 2.7 : figée.
- ▶ 3.x : présent et futur :
 - ▶ *better Unicode support*
 - ▶ Quelques inconsistences du langage (ex print 'a' vs print('a')).
 - ▶ Résultats de la division des entiers (1/2 : 2.x, = 0 ; 3.x, = 0.5).
 - ▶ ...
- ▶ Peut poser des problèmes :
 - ▶ Paquets portées sur 3.x ?
 - ▶ Compatibilité 64 bits ?

Outline

Introduction

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Description des paquets scientifiques

Distributions et Environnements de travail

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Type de base

- ▶ **Nombres** : entiers (int, long), réels (float), complex (complex), booléens (bool).
- ▶ **Séquences** : Chaînes de caractères (str), listes (list), tuples (tuple), dictionnaires (dict), ensembles (set)

Nombres

Entiers

- ▶ Attention à la division entière en 2.7.

```
>>> a = 1
>>> b = 2
>>> c = a / b
>>> print(c)
0
```

Nombres

Réels

- ▶ Utilisation du point pour passer en réels.

```
>>> a = 1.0  
>>> b = 2.  
>>> c = a / b  
>>> print(c)  
0.5
```

Nombres

Entiers long vs court

- ▶ Suffixe 'L' pour indiquer un passage en entier long.
- ▶ 'type()' indique le type d'une variable.

```
>>> a = 2 ** 30
>>> b = 2 ** 31
>>> a
1073741824
>>> b
2147483648L
>>> print(b)
2147483648
>>> type(a)
<type 'int'>
>>> type(b)
<type 'long'>
>>> c = 12345L
>>> type(c)
<type 'long'>
```

Nombres

Réels notations scientifiques

- ▶ Notation scientifique de type signe, mantisse et exposant.

```
>>> a = 1.234e100
>>> a
1.234e+100
>>> type(a)
<type 'float'>
```

Nombres

Complexes

- ▶ $z = x + yj$ (complex)
- ▶ Attention à la syntaxe.
- ▶ Génère une erreur (*exception*) de type "NameError".
- ▶ '_' variable courante (cf. *ans* matlab)

```
>>> a = 1 + 2j
>>> type(a)
<type 'complex'>
>>> a = 1 + j
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'j' is not defined
>>> 123.456j
123.456j
>>> type(_)
<type 'complex'>
>>> a = 1 + 1j
>>> b = 2 + 3j
>>> c = a + b
>>> print(c)
(3+4j)
```

Nombres

Booléens

- ▶ True, False (bool)
- ▶ Attention aux résultats des opérations sur les booléens.
- ▶ + donne un int
- ▶ Opérateurs booléens spécifiques.

```
>>> a = True
>>> type(a)
<type 'bool'>
>>> b = False
>>> c = a + b
>>> print(c)
1
>>> type(c)
<type 'int'>
>>> c = a * b
>>> print(c)
0
>>> c = a & b
>>> print(c)
False
>>> c = a | b
>>> print(c)
True
```

Nombres

Opérateurs

- ▶ Redéfinition des opérateurs selon les types.
- ▶ Pour les règles de priorités, cf 'language reference'.
- ▶ Bitwise operations on integer, cf 'language reference'.

entiers	+	addition	-	subtraction
	*	multiplication	/	division
	%	modulo	//	floor division
	**	power		
	«	shifting left	»	shifting right
réels	idem entiers hors shifting et bitwise op.			
complexes	idem réels			
booléens	&, and	and	, or	or
	^	xor	not	not

Nombres

Opérateurs de comparaisons

Comparaisons $>$, $<$, \geq , \leq , \equiv
 \neq , \neq (mieux, version C)
`in`, `not in` (sequence)
`is`, `is not` (objet)

```
>>> a = 1
>>> a in [0, 1, 2]
True
>>> b = 2
>>> a is b
False
>>> a is 1
True
>>> c = a
>>> a is c
True
>>> 0 < a <= 2
True
```

Nombres

Typage explicite, conversion de type

- ▶ possibilité de typer explicitement avec la fonction associée au type voulue : int(), float() ...
- ▶ conversion, implicite pour certaines opérations.

```
>>> a = float(9)
>>> type(a)
<type 'float'>
>>> c = 1 / a
>>> print(c)
0.111111111111
>>> b = 9
>>> c = 1 / float(b)
>>> print(c)
0.111111111111
>>> d = complex(1, 2)
>>> print(d)
(1+2j)
>>> print(str(d))
(1+2j)
```

Nombres et Caractères

Binary, Hexadecimal, Octal, Character, Unicode Character

- ▶ binary (0b) (bin), hexadecimal (0x) (hex), octal (0c) (oct)
- ▶ character (chr) (< 0xFF) ou unicode (unichr) (< 0xFFFF)

```
>>> a = 0x597d
>>> print(a)
22909
>>> a = 0b0101
>>> print(a)
5
>>> a = chr(42)
>>> print(a)
*
>>> b = unichr(0x597D)
>>> print(b)
chinese symbol ni
>>> a = bin(65447)
>>> print(a)
0b101100101111101
>>> type(a)
<type 'str'>
```

Séquences

Chaînes de caractères

- ▶ Texte délimité par ' ' ou " " (str)
- ▶ La chaîne de caractère a une longueur (len)

```
>>> a = 'abc'  
>>> type(a)  
<type 'str'>  
>>> b = "def"  
>>> c = a + b  
>>> c  
'abcdef'  
>>> len(c)  
6
```

Séquences

Chaînes de caractères

- ▶ Alternance des single/double quote.
- ▶ Caractères spéciaux à la C.

```
>>> a = "1. Bisque de pigeonneaux\n\t Prenez vos pigeonneaux apres qu'ils  
seront bien nettoyez\n\t&'Troussez', faites les blanchir, \n\t& Les " +  
'"empottez" avec un petit brin de fines herbes'  
>>> print(a)  
1. Bisque de pigeonneaux  
    Prenez vos pigeonneaux apres qu'ils seront bien nettoyez  
    & 'Troussez', faites les blanchir,  
    & Les "empottez" avec un petit brin de fines herbes
```

Séquences

Chaînes de caractères

- ▶ forme multiligne """ """ ou ''''' (! caractères spéciaux).
- ▶ Représentation (repr) différente de (str).

```
>>> a = """1. Bisque de pigeonneaux\n...
... \tPrenez vos pigeonneaux apres qu'ils seront bien nettoyez\n...
...     & 'Troussez', faites les blanchir,
...     & Les "empottez" avec un petit brun de fines herbes
... """
>>> print(a)
1. Bisque de pigeonneaux

    Prenez vos pigeonneaux apres qu'ils seront bien nettoyez

        & 'Troussez', faites les blanchir,
        & Les "empottez" avec un petit brun de fines herbes
>>> repr(a)
'\n1. Bisque de pigeonneaux\\n\\t\\tPrenez vos pigeonneaux apres qu\\\\',
ils seront bien nettoyez\\n\\n\\t& \\\\'Troussez\\\\', faites les blanchir,\\
\\n\\t& Les "empottez" avec un petit brun de fines herbes\\n\\'
>>> str(a)
"1. Bisque de pigeonneaux\\n\\n\\tPrenez vos pigeonneaux apres qu'ils seront bien
nettoyez\\n\\n    & 'Troussez', faites les blanchir, \\n    & Les "empottez" avec
un petit brun de fines herbes"
```

Séquences

Chaînes de caractères

- ▶ forme brute (`r" "` ou `r' '` ou `r"""" """"` ou `r'''' ''''`)
- ▶ forme unicode (`u" "` ou `u' '` ou `u"""" """"` ou `u'''' ''''`)

```
>>> a = r"Potage de santé\n\tLe potage de santé se fait de chapons..."  
>>> print(a)  
Potage de santé\n\tLe potage de santé se fait de chapons...  
>>> repr(a)  
"Potage de sant\\xc3\\xa9\\n\\\\\\tLe potage de sant\\xc3\\xa9 se fait  
de chapons..."  
>>> a = u"Potage de santé\n\tLe potage de santé se fait de chapons..."  
>>> print(a)  
Potage de santé  
    Le potage de santé se fait de chapons...  
>>> repr(a)  
"u'Potage de sant\\xe9\\n\\\\tLe potage de sant\\xe9 se fait de chapons...  
, "  
>>> print(u"\u4F60\u597D")
```

你好

Séquences

Listes

- ▶ Listes d'éléments (`[,]`, `list`)
- ▶ Longueur n (`len`)
- ▶ Accès aux élément : indices de 0 à $n - 1$

```
>>> a = [1, 2, 3]
>>> type(a)
<type 'list'>
>>> len(a)
3
>>> b = ['abc', 'de', 'fghij']
>>> len(b)
3
>>> c = a + b
>>> print(c)
[1, 2, 3, 'abc', 'de', 'fghij']
>>> c[0]
1
>>> c[5]
'fghij'
```

Séquences

Listes

- ▶ découpage, slicing (`:`, `i:`, `:j`, `i:j`, `i:j:k`, `slice(i,j,k)`)
- ▶ Indices négatifs de -1 à $-n$ permettent de parcourir en partant par la fin.

```
>>> a = [1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> a[:]
[1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> a[3:]
[4, 5, 6, 7, 8, 9]
>>> a[:3]
[1, 2, 3]
>>> a[2:2+4] # a[2:6]
[3, 4, 5, 6]
>>> a[2:6:2]
[3, 5]
>>> s = slice(2, 6, 2)
>>> a[s]
[3, 5]
>>> a[-1]
9
>>> a[-9]
1
```

Séquences

Listes

- ▶ Imbrications, nested.
- ▶ Attention aux erreurs d'indexation, les listes Python ne sont pas de matrices à la Matlab.

```
>>> a = [[1, 2, 3], [4, 5, 6]]
>>> a
[[1, 2, 3], [4, 5, 6]]
>>> len(a)
2
>>> a[0]
[1, 2, 3]
>>> a[0][0]
1
>>> a[0, 0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: list indices must be integers, not tuple
```

Séquences

Tuples

- ▶ Couple, triplet, n-uplet, plus généralement tuple ((,), tuple)
- ▶ Ce sont des séquences (de même que les types str, unicode, list, tuple, buffer, xrange) : même indexation que les listes.

```
>>> couple = ('papa', 'maman')
>>> type(couple)
<type 'tuple'>
>>> couple[0]
'papa'
>>> a = ('bob', 'alice')
>>> b = ('pierre', 'paul')
>>> c = a + b
>>> print(c)
('bob', 'alice', 'pierre', 'paul')
```

Séquences

Tuples

- ▶ Taille fixe immuable (immutable en anglais).
- ▶ Pratique pour le passage de paramètres de taille fixe.
- ▶ Affectation multiple implicite.
- ▶ On ne peut pas changer les valeurs des tuples.

```
>>> papa = 'bob'
>>> maman = 'alice'
>>> couple = (papa, maman)
>>> print(couple)
'bob', 'alice'
>>> couple = (papa, maman) = ('bob', 'alice')
>>> couple = papa, maman = 'bob', 'alice'
>>> couple[0] = 'robert'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'tuple' object does not support item assignment
```

Séquences

Tuples

- ▶ Attention : couples immuables, listes muables

```
>>> address = '0001'  
>>> instr = '011'  
>>> code1 = (instr, address)  
>>> code2 = ('100', '0010')  
>>> code3 = ('110', '0011')  
>>> code4 = ('010', '0001')  
>>> prog = [code1, code2, code3]  
>>> prog.append(code4)  
>>> print(prog)  
[('011', '0001'), ('100', '0010'), ('110', '0011'), ('010', '0001')]
```

Séquences

Tuples

- ▶ Exemple de liste de couples.

```
>>> name = 'abc'
>>> value = 123
>>> entry1 = (name, value)
>>> entry2 = ('def', 234)
>>> dictionary = [entry1, entry2]
>>> dictionary.append(('efg', 345))
>>> print(dictionary)
[('abc', 123), ('def', 234), ('efg', 345)]
```

Séquences

Dictionnaires

- ▶ Dictionnaires (dict)
- ▶ key (str): value

```
>>> d = {'abc': 123, 'def': 234}
>>> type(d)
<type 'dict'>
>>> print(d)
{'abc': 123, 'def': 234}
>>> d['abc']
123
>>> for key in d:
...     print((key, d[key]))
...
('abc', 123)
('def', 234)
```

Séquences

Ensemble

- ▶ Ensemble (`{ , }`, `set`)
- ▶ Collections d'éléments uniques non ordonnés.
- ▶ Opération ensemblistes (`add`, `discard`, `union`, `intersect`, ...)

```
>>> E = {1, 2, 3}
>>> type(E)
<type 'set'>
>>> print(E)
set([1, 2, 3])
>>> E[0]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'set' object does not support indexing
>>> F = {1, 2, 3, 2, 1, 4, 1, -1}
>>> F
set([1, 2, 3, 4, -1])
>>> a = 1
>>> a in F
True
>>> G = E + F
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for +: 'set' and 'set'
>>> E.intersection(F)
set([1, 2, 3])
>>> E.add(-10)
>>> print(E)
set([1, 2, 3, -10])
```

Syntaxe

- ▶ Fonctions prédéfinies, 'Builtin' Functions
- ▶ Structures de contrôles
- ▶ Fonctions
- ▶ Objets et Classes

Syntaxe

Fonctions prédéfinies

► Built-in Functions : fonctions de base du langage.

abs()	divmod()	input()	open()	staticmethod()
all()	enumerate()	int()	ord()	str()
any()	eval()	isinstance()	pow()	sum()
basestring()	execfile()	issubclass()	print()	super()
bin()	file()	iter()	property()	tuple()
bool()	filter()	len()	range()	type()
bytearray()	float()	list()	raw_input()	unichr()
callable()	format()	locals()	reduce()	unicode()
chr()	frozenset()	long()	reload()	vars()
classmethod()	getattr()	map()	repr()	xrange()
cmp()	globals()	max()	reversed()	zip()
compile()	hasattr()	memoryview()	round()	__import__()
complex()	hash()	min()	set()	apply()
delattr()	help()	next()	setattr()	buffer()
dict()	hex()	object()	slice()	coerce()
dir()	id()	oct()	sorted()	intern()

Syntaxe

Fonctions prédéfinies

► Built-in Functions : fonctions de base du langage.

<code>abs()</code>	<code>divmod()</code>	<code>input()</code>	<code>open()</code>	<code>staticmethod()</code>
<code>all()</code>	<code>enumerate()</code>	<code>int()</code>	<code>ord()</code>	<code>str()</code>
<code>any()</code>	<code>eval()</code>	<code>isinstance()</code>	<code>pow()</code>	<code>sum()</code>
<code>basestring()</code>	<code>execfile()</code>	<code>issubclass()</code>	<code>print()</code>	<code>super()</code>
<code>bin()</code>	<code>file()</code>	<code>iter()</code>	<code>property()</code>	<code>tuple()</code>
<code>bool()</code>	<code>filter()</code>	<code>len()</code>	<code>range()</code>	<code>type()</code>
<code>bytearray()</code>	<code>float()</code>	<code>list()</code>	<code>raw_input()</code>	<code>unichr()</code>
<code>callable()</code>	<code>format()</code>	<code>locals()</code>	<code>reduce()</code>	<code>unicode()</code>
<code>chr()</code>	<code>frozenset()</code>	<code>long()</code>	<code>reload()</code>	<code>vars()</code>
<code>classmethod()</code>	<code>getattr()</code>	<code>map()</code>	<code>repr()</code>	<code>xrange()</code>
<code>cmp()</code>	<code>globals()</code>	<code>max()</code>	<code>reversed()</code>	<code>zip()</code>
<code>compile()</code>	<code>hasattr()</code>	<code>memoryview()</code>	<code>round()</code>	<code>__import__()</code>
<code>complex()</code>	<code>hash()</code>	<code>min()</code>	<code>set()</code>	<code>apply()</code>
<code>delattr()</code>	<code>help()</code>	<code>next()</code>	<code>setattr()</code>	<code>buffer()</code>
<code>dict()</code>	<code>hex()</code>	<code>object()</code>	<code>slice()</code>	<code>coerce()</code>
<code>dir()</code>	<code>id()</code>	<code>oct()</code>	<code>sorted()</code>	<code>intern()</code>

déjà rencontrées

Syntaxe

Fonctions prédéfinies

► Built-in Functions : fonctions de base du langage.

<code>abs()</code>	<code>divmod()</code>	<code>input()</code>	<code>open()</code>	<code>staticmethod()</code>
<code>all()</code>	<code>enumerate()</code>	<code>int()</code>	<code>ord()</code>	<code>str()</code>
<code>any()</code>	<code>eval()</code>	<code>isinstance()</code>	<code>pow()</code>	<code>sum()</code>
<code>basestring()</code>	<code>execfile()</code>	<code>issubclass()</code>	<code>print()</code>	<code>super()</code>
<code>bin()</code>	<code>file()</code>	<code>iter()</code>	<code>property()</code>	<code>tuple()</code>
<code>bool()</code>	<code>filter()</code>	<code>len()</code>	<code>range()</code>	<code>type()</code>
<code>bytearray()</code>	<code>float()</code>	<code>list()</code>	<code>raw_input()</code>	<code>unichr()</code>
<code>callable()</code>	<code>format()</code>	<code>locals()</code>	<code>reduce()</code>	<code>unicode()</code>
<code>chr()</code>	<code>frozenset()</code>	<code>long()</code>	<code>reload()</code>	<code>vars()</code>
<code>classmethod()</code>	<code>getattr()</code>	<code>map()</code>	<code>repr()</code>	<code>xrange()</code>
<code>cmp()</code>	<code>globals()</code>	<code>max()</code>	<code>reversed()</code>	<code>zip()</code>
<code>compile()</code>	<code>hasattr()</code>	<code>memoryview()</code>	<code>round()</code>	<code>__import__()</code>
<code>complex()</code>	<code>hash()</code>	<code>min()</code>	<code>set()</code>	<code>apply()</code>
<code>delattr()</code>	<code>help()</code>	<code>next()</code>	<code>setattr()</code>	<code>buffer()</code>
<code>dict()</code>	<code>hex()</code>	<code>object()</code>	<code>slice()</code>	<code>coerce()</code>
<code>dir()</code>	<code>id()</code>	<code>oct()</code>	<code>sorted()</code>	<code>intern()</code>

abordées tôt ou tard

Syntaxe

Structure de contrôle

- ▶ **blocs conditionnels** : if else
- ▶ **boucles conditionnelles** : while
- ▶ **boucles** : for in
- ▶ **gestion d'exceptions** : try except

Syntaxe

Structure de contrôle - if else

- ▶ blocs conditionnels : if else
- ▶ ':' et indentation suivie d'un bloc d'instruction.

```
>>> a = 1
>>> if (a == 1):
...     print("a vaut 1")
... else:
...     print("a ne vaut pas 1")
...
a vaut 1
```

Syntaxe

Indentation

- ▶ Pour l'indentation dans un fichier, il est conseillé d'utiliser 4 espaces plutôt qu'une tabulation.
- ▶ Possibilité de régler ce paramètres dans les éditeurs de texte : tabulation souple émulée avec des espaces ('soft tab' with 4 spaces vs 'hard tab').

```
if (a == 1):  
    print("a vaut 1")  
else:  
    print("a ne vaut pas 1")
```

Syntaxe

Structure de contrôle - if elif else

- ▶ blocs conditionnels : if elif else

```
>>> a = 2
>>> if (a == 1):
...     print("a vaut 1")
... elif a == 2:
...     print("a vaut 2")
... elif a == 3:
...     print("a vaut 3")
... else:
...     print("a ne vaut ni 1 ni 2 ni 3")
...
a vaut 2
```

cf matlab (if elseif else end, switch case otherwise end)

Syntaxe

Structure de contrôle - if elif else

- ▶ blocs conditionnels : if elif else

```
>>> a = "green"
>>> if (a is "green"):
...     print("00FF00")
... elif (a == "red"):
...     print("FF0000")
... elif (a is "blue"):
...     print("0000FF")
... else:
...     print("Unknown color")
...
00FF00
```

cf matlab (if elseif else end, switch case otherwise end)

Syntaxe

Structure de contrôle - while

► boucles conditionnelles : while

```
>>> question = "Voulez-vous continuer ? (o, oui, O, OUI) "
>>> cond = True
>>> reponseOK = {"o", "O", "oui", "OUI"}
>>> i = 0
>>> while cond:
...     i += 1
...     print(str(i) + " fois")
...     answer = input(question)
...     if (answer in reponseOK):
...         cond = True
...     else:
...         cond = False
...
1 fois
Voulez-vous continuer ? (o, oui, O, OUI) 'o'
2 fois
Voulez-vous continuer ? (o, oui, O, OUI) 'oui'
3 fois
Voulez-vous continuer ? (o, oui, O, OUI) 'non'
>>>
```

Syntaxe

Structure de contrôle - for

- ▶ boucles : for in :
- ▶ Dans 'language reference' :
for_stmt ::= "for" target_list "in" expression_list ":" suite
["else" ":" suite]

```
>>> for i in [0, 1, 2, 3]:  
...     print(i)  
...  
0  
1  
2  
3
```

Syntaxe

Structure de contrôle - for

- ▶ une étendue (range) de $[0, n]$: range(n)
- ▶ $[i, i + k, \dots, j[$: range(i, j, k)

```
>>> for i in range(4):
...     print(i)
...
0
1
2
3
```

```
>>> x = [0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
>>> x[range(1, 5, 2)]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: list indices must be integers, not list
>>> x[slice(1, 5, 2)]
[1, 3]
>>> range(1, 5, 2)
[1, 3]
>>> slice(1, 5, 2)
slice(1, 5, 2)
```

Syntaxe

Structure de contrôle - for

- ▶ boucles : for

```
>>> for (i, j) in [(1, 2), (2, 3), (3, 4)]:  
...     print((i,j))  
...  
(1, 2)  
(2, 3)  
(3, 4)
```

```
>>> for [i, j] in [[1, 2], [2, 3], [3, 4]]:  
...     print([i, j])  
...  
[1, 2]  
[2, 3]  
[3, 4]
```

Syntaxe

Structure de contrôle - break, continue

- ▶ possibilité de break et continue.

```
>>> for i in range(10):
...     if (i % 2 == 0):
...         continue
...     if (i == 9):
...         break
...     print(i)
...
1
3
5
7
```

Syntaxe

Structure de contrôle - try except

- ▶ Gestion des erreurs ou exceptions : try except

```
>>> a = "abc"
>>> a += 1
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: cannot concatenate 'str' and 'int' objects
```

```
>>> a = 'abc'
>>> try:
...     a += 1
... except :
...     print("problem")
...
problem
```

Syntaxe

Structure de contrôle - try except else finally

- ▶ Gestion des erreurs ou exceptions : try except else finally

```
>>> a = 'abc'
>>> try:
...     a += 1
... except IOError as e :
...     print("problem entrées sorties : " + str(e))
... except TypeError as e :
...     print("problem de types : " + str(e))
... finally:
...     print("Avec ou sans erreurs, on continue")
...
problem de types : cannot concatenate 'str' and 'int' objects
Avec ou sans erreurs, on continue
```

```
>>> a = 1
>>> try:
...     a += 1
... except IOError as e :
...     print("problem entrées sorties : " + str(e))
... except TypeError as e :
...     print("problem de types : " + str(e))
... else:
...     print("a = " + str(a))
... finally:
...     print("Avec ou sans erreurs, on continue")
...
a = 2
Avec ou sans erreurs, on continue
```

Syntaxe

Fonctions - Définition de la fonction

- ▶ définition d'une fonction : "def" funcname "(" [parameter_list] ")" ":" suite
- ▶ indentation nécessaire pour le bloc d'instructions.

```
>>> def sayHello():
...     print("Hello")
...
>>> sayHello()
Hello
```

Syntaxe

Fonctions - passage de paramètres obligatoires

- ▶ Les arguments (dit args) sont définis entre parenthèse.
- ▶ args : obligatoires et ordonnés

```
>>> def sayHello(titre, prenom, nom):  
...     print("Hello " + str(titre) + " " + str(prenom) + " " + str(nom))  
...  
>>> sayHello("déTECTIVE PRIVé DE CLASSE R", "John", "Difool")  
Hello déTECTIVE PRIVé DE CLASSE R John Difool
```

```
>>> sayHello()  
Traceback (most recent call last):  
  File "<stdin>", line 1, in <module>  
TypeError: sayHello() takes exactly 3 arguments (0 given)
```

Syntaxe

Fonctions - passage de paramètres optionnels

- ▶ arguments mots clés (keywords arguments dits kwargs) non obligatoires.
- ▶ args avant les kwargs
- ▶ kwargs : optionnels et non ordonnés

```
>>> def sayHello(titre, prenom="", nom=""):  
...     print("Hello " + str(titre) + " " + str(prenom) + " " + str(nom))  
...  
>>> sayHello("old")  
Hello old  
>>> sayHello("old", prenom="Nick")  
Hello old Nick  
>>> sayHello("old", "Tom", "Bombadil")  
Hello old Tom Bombadil  
>>> sayHello("old", nom="Bombadil", prenom="Tom")  
Hello old Tom Bombadil  
>>> sayHello(nom="Bombadil")  
Traceback (most recent call last):  
  File "<stdin>", line 1, in <module>  
TypeError: sayHello() takes at least 1 argument (1 given)  
>>> sayHello("old", nom="Bombadil", "Tom")  
  File "<stdin>", line 1  
SyntaxError: non-keyword arg after keyword arg
```

Syntaxe

Fonctions - renvoi de valeurs

- ▶ renvoi de valeurs : return

```
>>> def fun(x):
...     y = 2 * x
...     return y
...
>>> fun(3)
6
```

```
>>> def fun(x):
...     y1 = x
...     y2 = 2 * x
...     y3 = 3 * x
...     name = "1, 2, 3 * " + str(x) + " = "
...     return name, y1, y2, y3 # the tuple (name, y1, y2, y3)
...
>>> fun(3)
('1, 2, 3 * 3 = ', 3, 6, 9)
>>> (name, y1, y2, y3) = fun(3)
>>> name, y1, y2, y3 = fun(3)
```

Syntaxe

Fonctions - autres spécificités

- ▶ bloc vide : pass
- ▶ None values
- ▶ variables de fonctions

```
>>> def fonctionQuiNeFaitRienEtQuiAUnNomHorribleMaisDescriptif(x):
...     pass
...
>>> def fonctionQuiNeFaitRienEtQuiAUnNomHorribleMaisDescriptif(x):
...     return
...
>>> def fonctionQuiNeFaitRienEtQuiAUnNomHorribleMaisDescriptif(x):
...     return None
...
>>> a = fonctionQuiNeFaitRienEtQuiAUnNomHorribleMaisDescriptif(3)
>>> a == None
True
>>> pfff = fonctionQuiNeFaitRienEtQuiAUnNomHorribleMaisDescriptif
>>> pfff(1)
>>> pfff("abc")
>>> pfff
<function fonctionQuiNeFaitRienEtQuiAUnNomHorribleMaisDescriptif at 0x2d49b0>
```

Syntaxe

Objets - Notion de programmation orientée objet

- ▶ Un objet possède :
 - ▶ des propriétés ou attributs, variables spécifiques à l'objet.
 - ▶ des méthodes, fonctions qui permettent de communiquer entre objets ou avec l'extérieur.
- ▶ Un objet appartient à une classe: *Un objet est une instance de classe.*
- ▶ Les propriétés et méthodes sont définies dans la classe.

```
3 canards : riri, fifi, loulou

classe Canard :
propriétés, attributs : 2 pattes, 2 ailes, état d'activité
méthodes : manger, chanter, ne rien faire.

Canard :
à 2 pattes
à 2 ailes
status par défaut : ne fais rien

mange(aliments)
vérification aliments : herbivore, carnivore occasionnel

chante()
génère un son qui fait "couin couin"

ne fait rien()
```

Syntaxe

Objets : définition en Python

- ▶ Définition d'une nouvelle : "class" classname ":" suite
- ▶ propriétés : variables avec une valeur par défaut.
- ▶ méthodes : fonctions avec le premier argument l'objet lui même par convention 'self'

```
>>> class Canard:  
...     pattes = 2  
...     ailes = 2  
...     status = "en attente"  
...     def mange(self, aliment):  
...         self.status = "mange"  
...         if aliment in {"grain", "feuille", "fleur", "tige", "racine"}:  
...             print("miam")  
...         elif aliment in {"ver", "insecte", "friture"}:  
...             print("j'avais faim")  
...         else :  
...             print("non merci")  
...     def chante(self):  
...         self.status = "chante"  
...         print("couin couin")  
...     def espere(self):  
...         self.status = "en attente"  
...         return 0  
...
```

Syntaxe

Objets : définition en Python

- ▶ `__init__` : création lors de l'instanciation. Il est conseillé d'initialiser les attributs dans ce bloc.

```
>>> class Canard:  
...     def __init__(self):  
...         self.pattes = 2  
...         self.ailes = 2  
...         self.status = "en attente"  
...
```

Syntaxe

Objets : instantiation et usage

- ▶ instantiation : objet = Classname()
- ▶ propriétés obtenues par : objet.property (cf structure en C)
- ▶ méthodes obtenues par : objet.method(argument)

```
>>> riri = Canard()
>>> riri
<__main__.Canard instance at 0x2c8760>
>>> fifi = Canard()
>>> loulou = Canard()
>>> riri.ailes
2
>>> riri.status
en attente
>>> riri.chante()
couin couin
>>> loulou.mange("grain")
miam
>>> riri.status, loulou.status, fifi.status
('chante', 'mange', 'en attente')
>>> fifi.espere()
0
>>> dir(riri)
['__doc__', '__module__', 'ailes', 'chante', 'espere', 'mange', 'pattes',
'status']
```

Syntaxe

Objets : exemple avec des nombres

- En python toutes les variables sont des objets.

```
>>> a = 123
>>> dir(a)
['__abs__', '__add__', '__and__', '__class__', '__cmp__', '__coerce__',
 '__delattr__', '__div__', '__divmod__', '__doc__', '__float__', '__floordiv__',
 '__format__', '__getattribute__', '__getnewargs__', '__hash__', '__hex__',
 '__index__', '__init__', '__int__', '__invert__', '__long__', '__lshift__',
 '__mod__', '__mul__', '__neg__', '__new__', '__nonzero__', '__oct__', '__or__',
 '__pos__', '__pow__', '__radd__', '__rand__', '__rdiv__', '__rdivmod__',
 '__reduce__', '__reduce_ex__', '__repr__', '__rfloordiv__', '__rlshift__',
 '__rmod__', '__rmul__', '__ror__', '__rpow__', '__rrshift__', '__rshift__',
 '__rsub__', '__rtruediv__', '__rxor__', '__setattr__', '__sizeof__', '__str__',
 '__sub__', '__subclasshook__', '__truediv__', '__trunc__', '__xor__',
 'bit_length', 'conjugate', 'denominator', 'imag', 'numerator', 'real']
>>> type(a)
<type 'int'>
>>> a.real
123
>>> a.bit_length()
7
```

Syntaxe

Objets : exemple avec les listes et les tuples

```
>>> a = [1, 2, 3, 1, 2]
>>> dir(a)
[..., 'append', 'count', 'extend', 'index', 'insert', 'pop',
'remove', 'reverse', 'sort']
>>> type(a)
<type 'list'>
>>> a.append(3)
>>> a
[1, 2, 3, 1, 2, 3]
>>> a.pop()
>>> a
[1, 2, 3, 1, 2]
```

```
>>> a = (1, 2, 3, 1, 2)
>>> dir(a)
[..., 'count', 'index']
>>> type(a)
<type 'tuple'>
>>> a.count(1)
2
>>> a.index(1)
0
```

Syntaxe

Objets : exemple avec les chaînes de caractères

```
>>> a = "abc.def"
>>> dir(a)
[..., 'capitalize', 'center', 'count', 'decode', 'encode', 'endswith',
'expandtabs', 'find', 'format', 'index', 'isalnum', 'isalpha', 'isdigit',
'islower', 'isspace', 'istitle', 'isupper', 'join', 'ljust', 'lower', 'lstrip',
'partition', 'replace', 'rfind', 'rindex', 'rjust', 'rpartition', 'rsplit',
'rrstrip', 'split', 'splitlines', 'startswith', 'strip', 'swapcase', 'title',
'translate', 'upper', 'zfill']
>>> a.upper()
ABC.DEF
>>> a.index('.')
3
>>> (head, sep, tail) = a.partition('.')
('abc', '.', 'def')
>>> (head, sep, tail) = a.partition('.')
>>> head
'abc'
```

Syntaxe

Fichiers

- ▶ un fichier est considéré comme un objet de classe 'file'.

```
>>> f = file("cuisinierFrancois.txt", 'r')
>>> f
<open file 'cuisinierFrancois.txt', mode 'r' at 0x2a2390>
>>> dir(f)
dir(f)
[..., 'close', 'closed', 'encoding', 'errors', 'fileno', 'flush',
 'isatty', 'mode', 'name', 'newlines', 'next', 'read', 'readinto',
 'readline', 'readlines', 'seek', 'softspace', 'tell', 'truncate',
 'write', 'writelines', 'xreadlines']
>>> f.readlines()
['LE CUISINIER FRANCOIS, \n', '\n', 'ENSEIGNANT LA MANIERE\n', 'de
bien apprester & assaisonner\n', 'toutes sortes de Viandes grasses
\n', '& maigres, Legumes, Patisseries, \n', '& autres mets qui se
servent tant\n', 'sur les Tables des Grands que des\n', 'particuli
ers. \n', '\n', '\n']
>>> f.seek(0)
>>> for line in f:
...     print(line)
...
LE CUISINIER FRANCOIS,
ENSEIGNANT LA MANIERE
de bien apprester & assaisonner
toutes sortes de Viandes grasses
& maigres, Legumes, Patisseries,
& autres mets qui se servent tant
sur les Tables des Grands que des
particuliers.
```

Module

Exécution dans le shell

- ▶ Enregistrement du code dans un fichier module1.py
- ▶ Contient des définitions des classes ou de fonctions, des scripts, une documentation (docstring).
- ▶ Exécution du code dans le shell : python module1.py

```
def f1(x):  
    y = 10 * x  
    return y  
def f2(x):  
    y = 100 * x  
    return y  
x = 3  
y1 = f1(x)  
y2 = f2(x)  
print("(x, y1, y2) : " + str((x, y1, y2)))
```

```
~/python/example/module> python module1.py  
(x, y1, y2) : (3, 30, 300)
```

Module

Importation de code : import

- ▶ Importation du code dans la console ou dans un autre module : import
- ▶ Variante en modifiant l'espace de nom (namespace) : import ... as fun

```
import module1
x = 4
y1 = module1.f1(x)
y2 = module1.f2(x)
print("module -> (x, y1, y2) : " + (x, y1, y2))
```

```
import moduleQuiAUnNomBeaucoupTropLong as myFun
x = 4
y1 = myFun.f1(x)
y2 = myFun.f2(x)
print("module -> (x, y1, y2) : " + (x, y1, y2))
```

```
(x, y1, y2) : (3, 30, 300)
module -> (x, y1, y2) : (4, 40, 400)
```

Module

Importation de code : import

- ▶ importation spécifique d'une ou plusieurs fonctions : from ... import (f1, f2) ; from ... import (f1 as fun1, f2 as fun2) ; from ... import f1 as fun1, f2 as fun2
- ▶ from ... import *

```
>>> from module1 import f1
>>> f1(5)
50
```

```
>>> from module1 import f1 as fois10
>>> fois10(5)
50
```

```
>>> from module1 import *
>>> dir()
[..., 'f1', 'f2', 'x', 'y1', 'y2']
```

```
>>> import module1
>>> dir()
[..., 'module1']
>>> type(module1)
<type 'module'>
>>> dir(module1)
[..., 'f1', 'f2', 'x', 'y1', 'y2']
```

Module

Espace : `__name__`

- ▶ attribut système : '`__name__`'

```
print("Affichage en import ou en exécution")
print("__name__ : " + str(__name__))

if="__name__" == "__main__":
    print("Que si executé de l'extérieur")
```

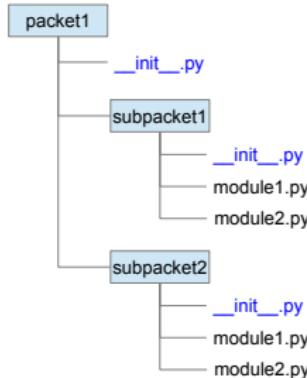
```
>>> import moduleMain
Affichage en import ou en exécution
__name__ : moduleMain
```

```
~/python/example/module> python moduleMain.py
Affichage en import ou en exécution
__name__ : __main__
```

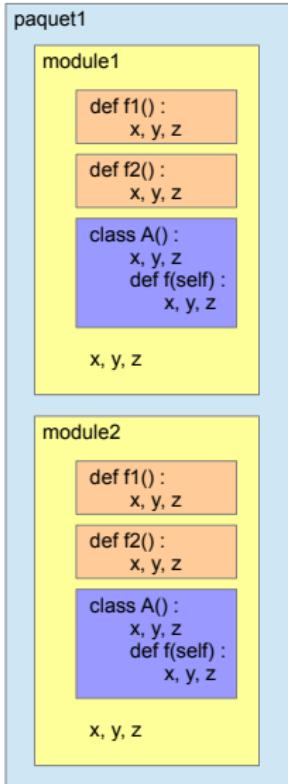
Paquet

- ▶ Un dossier contenant :
 - ▶ des modules
 - ▶ un fichier '`__init__.py`', vide ou non.
- ▶ exemple : `packet1/subpacket1/module1.py` ;
`packet1/subpacket2/module2.py`
- ▶ possibilité de faire des sous-paquet.

```
>>> from packet1.subpacket1 import module1 as mod1
```



Portée



- ▶ paquet, module, def, class : chaque niveau à sa portée (scope).
- ▶ Attention à l'espace des noms (namespace) : par exemple, `f1` est disponible dans `module1` et `module2`.

```
>>> import paquet1
>>> x = 10
>>> a1 = paquet1.module1.A
>>> a2 = paquet1.module2.A
>>> a2.f()
>>> resF1 = paquet1.module1.f1(x)
>>> resF2 = paquet1.module2.f2(x)
>>> from paquet1.module1 import * # A EVITER
>>> resF1 = f1(x)
```

Standard library

- ▶ Un ensemble de paquets et modules sont déjà livrés avec Python (Battery included) : math, os, sys, datetime ...
- ▶ Avant de recoder quelque chose, vérifier si cela existe dans la documentation : 'The Python Library Reference'.

Exemple

Math

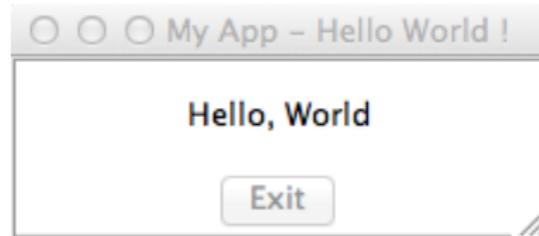
```
>>> import math
>>> dir(math)
['__doc__', '__file__', '__name__', '__package__', 'acos', 'acosh',
'asin', 'asinh', 'atan', 'atan2', 'atanh', 'ceil', 'copysign', 'cos', 'cosh',
'degrees', 'e', 'erf', 'erfc', 'exp', 'expm1', 'fabs', 'factorial', 'floor',
'fmod', 'frexp', 'fsum', 'gamma', 'hypot', 'isinf', 'isnan', 'ldexp',
'lgamma', 'log', 'log10', 'log1p', 'modf', 'pi', 'pow', 'radians', 'sin',
'sinh', 'sqrt', 'tan', 'tanh', 'trunc']
>>> math.cos(math.pi/3)
0.5000000000000001
```

Exemple

Graphical User Interface / GUI

- ▶ interface graphique pour Tk (Tkinter), GTK (PyGTK), wxWidgets (wxPython), Qt (PyQt).

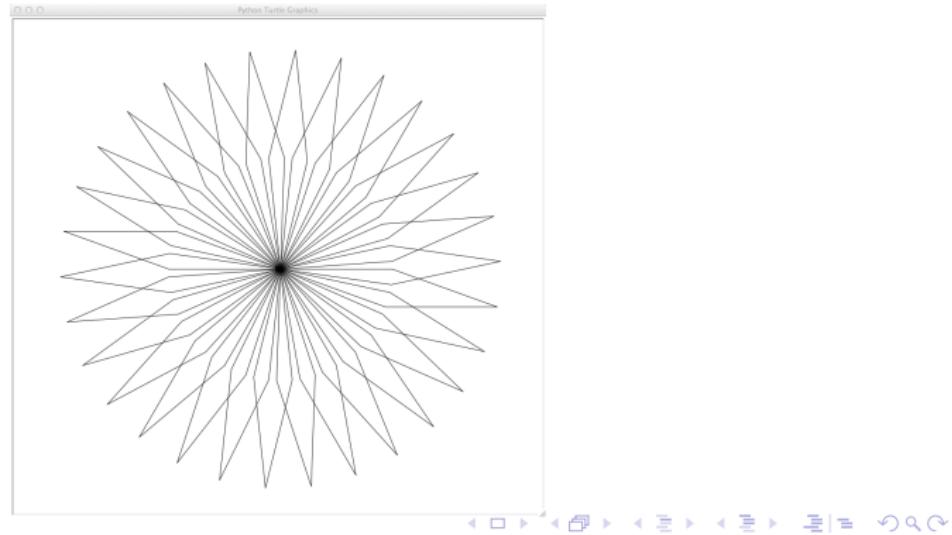
```
>>> import Tkinter
>>> from Tkconstants import *
>>> tk = Tkinter.Tk()
>>> tk.title("My App - Hello World !")
>>> frame = Tkinter.Frame(tk, relief=RIDGE, borderwidth=2)
>>> frame.pack(fill=BOTH,expand=1)
>>> label = Tkinter.Label(frame, text="Hello, World")
>>> label.pack(fill=X, expand=1)
>>> button = Tkinter.Button(frame, text="Exit", command=tk.destroy)
>>> button.pack(side=BOTTOM)
>>> tk.mainloop()
```



Exemple

Graphical User Interface / GUI

```
>>> import turtle  
>>> for i in range(30):  
...     turtle.forward(200)  
...     turtle.rt(20)  
...     turtle.forward(200)  
...     turtle.rt(160)  
...     turtle.forward(200)  
...     turtle.rt(20)  
...     turtle.forward(200)  
...     turtle.rt(172)  
...  
...
```



Exemple

Base de données

```
>>> import sqlite3
>>> db = sqlite3.connect("myDB(sq3")
>>> cur = db.cursor()
>>> cur.execute("CREATE TABLE membres
    (nom TEXT, prenom TEXT, institut TEXT)")
>>> cur.execute("INSERT INTO membres(nom,prenom,institut)
    VALUES('Michel','Olivier','INPG')")
>>> cur.execute("INSERT INTO membres(nom,prenom,institut)
    VALUES('Brossier','Jean-Marc','UJF')")
>>> cur.execute("INSERT INTO membres(nom,prenom,institut)
    VALUES('Amblard','Pierre-Olivier','CNRS')")
>>> db.commit()
>>> cur.execute("SELECT * FROM membres WHERE institut = 'CNRS'")
>>> list(cur)
[(u'Amblard', u'Pierre-Olivier', u'CNRS')]
>>> db.close()
```

Documentation

docstrings

- ▶ Commentaires : ligne qui commence par #
- ▶ Texte de documentation (Docstring): *Une chaîne de caractères qui apparaît comme première expression dans un module, une fonction ou une classe.*
- ▶ """ recommandé (see PEP257 :
<http://www.python.org/dev/peps/pep-0257/>)

```
def times(x, y):
    """
    Multiply x by y

    Compute z = x * y

    Input parameters
    x and y, any numbers

    Output parameters
    z

    Copyright 2013 G. Becq, Gipsa-lab, UMR 5216, CNRS.
    """
    return x * y
```

Documentation

docstrings – exemple

- ▶ Première ligne est un résumé suivi d'une ligne vide.
- ▶ Première ligne vide et indentation seront effacées.

```
# -*- encoding:utf-8 -*-
"""
Module pour tester les docstrings.

Contient deux fonctions et une classe.
Ne fait rien.

Copyright 2013 G. Becq, Gipsa-lab, UMR 5216, CNRS.
"""

def fun1():
    """
    fun1 c'est bien.

    Fonction sans parametres
    Ne fait rien.
    """
    print("blah blah")
    """
    Ce texte ne sera pas visible
    """
    print("blah blah")
    "Ce texte non plus, les declarations vides non plus"
    1
    print("blah blah")
    # Ca c'est un vrai commentaire delimité par un hash
    return
```

Documentation

docstrings – exemple

```
def fun2():
    """
    fun2 c'est mieux.

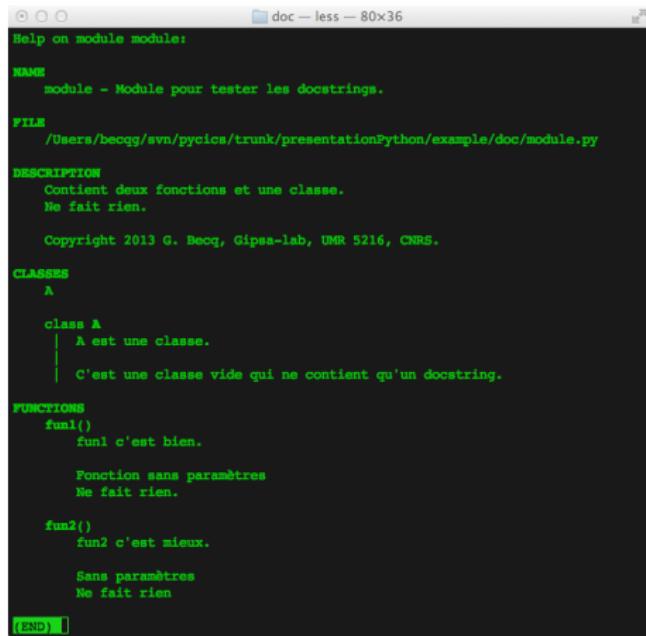
    Sans parametres
    Ne fait rien
    """
    return

class A():
    """
    A est une classe.

    C'est une classe vide qui ne contient qu'un docstring.
    """
```

Documentation help

- ▶ Génération automatique de documentation :
`help(nomDuModule)`



```
Help on module module:

NAME
    module - Module pour tester les docstrings.

FILE
    /Users/becqg/svn/pycics/trunk/presentationPython/exemple/doc/module.py

DESCRIPTION
    Contient deux fonctions et une classe.
    Ne fait rien.

    Copyright 2013 G. Becq, Gipes-lab, UMR 5216, CNRS.

CLASSES
    A

        class A
            |
            A est une classe.
            |
            C'est une classe vide qui ne contient qu'un docstring.

FUNCTIONS
    fun1()
        fun1 c'est bien.

        Fonction sans paramètres
        Ne fait rien.

    fun2()
        fun2 c'est mieux.

        Sans paramètres
        Ne fait rien

(END) [ ]
```

Documentation

pydoc

- ▶ Dans le shell 'pydoc -g', lance un serveur de documentation accessible via un navigateur.
- ▶ 'pydoc' génère aussi d'autres sorties.



Packaging

- ▶ Repose sur *distutils* de la bibliothèque standard.
- ▶ Créer un fichier 'setup.py' qui contient des metadonnées.

```
from distutils.core import setup
setup(name="distrib1",
      description="une distribution de démos",
      version="1.0",
      author="Guillaume Becq",
      author_email="guillaume.becq@gipsa-lab.grenoble-inp.fr",
      url="http://example.iana.org",
      py_modules=["module1", "module2"],
      )
```

Packaging

- ▶ Distribution : fichier compressé de type 'zip' ou '.tar.gz'
- ▶ Exécuter dans un terminal "python setup.py sdist"
- ▶ Génère :
 - ▶ un dossier 'dist' : contenant la distribution.
 - ▶ un fichier MANIFEST : liste des fichiers inclus dans le paquet.
- ▶ possibilité d'utiliser MANIFEST.in pour dire quels fichiers à inclure.
- ▶ Faire un README.txt sinon warning.

```
~/myPackage> python setup.py sdist
writing manifest file 'MANIFEST',
creating packet1-1.0
making hard links in packet1-1.0...
hard linking setup.py -> packet1-1.0
creating dist
Creating tar archive
removing 'packet1-1.0' (and everything under it)
~/myPackage> cd dist
~/myPackage/dist> ls
packet1-1.0.tar.gz
```

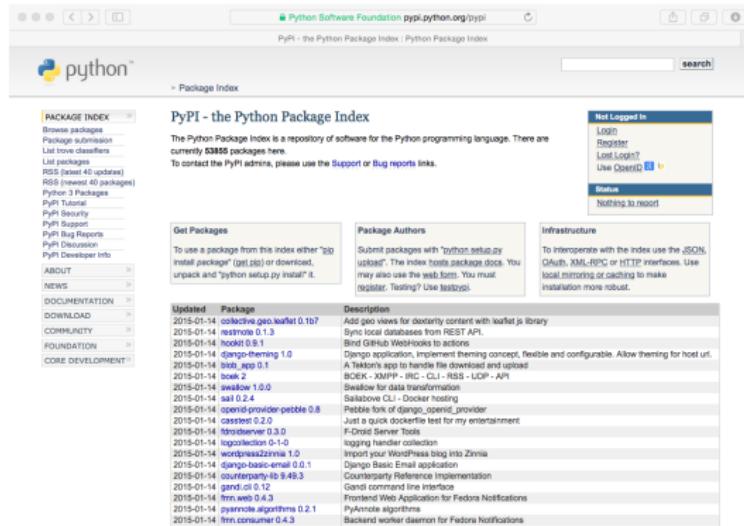
Installation des paquets

- ▶ Décompresser le paquet : il existe une bibliothèque 'tarfile' dans la librairie standard de Python qui permet de décompresser les fichiers 'tar'.
- ▶ Exécuter dans un terminal : "python setup.py"
- ▶ L'installation se fait dans "PYTHONHOME/site-packages".

```
~/tempdir/packageToInstall> python setup.py install
```

Python Package Index

- ▶ Python Package Index : PyPI
<https://pypi.python.org/pypi>
- ▶ Base de données de paquets disponibles.



The screenshot shows the PyPI homepage with the following visible content:

- Header:** Python Software Foundation pypi.python.org/pypi | PyPI - the Python Package Index : Python Package Index
- Left Sidebar (PACKAGE INDEX):**
 - Browse packages
 - Package submission
 - List trove classifiers
 - List packages
 - (List latest 40 updated)
 - RSS feed (Atom feed)
 - Python 3 Packages
 - PyPI Tutorial
 - PyPI Security
 - PyPI License
 - PyPI Bug Reports
 - PyPI Discussion
 - PyPI Developer Info
- Center Content:**
 - Get Packages**: Instructions for installing packages via pip or setup.py.
 - Package Authors**: Instructions for submitting packages with setup.py upload.
 - Infrastructure**: Information on interfacing with the index using various protocols.
 - Recent Updates** table (partial):

Updated	Package	Description
2015-01-14	collective.geo.loftlet 0.1b1	Add geo views for decency content with loftlet js library
2015-01-14	restnre 0.1.3	Sync local databases from REST API
2015-01-14	hookit 0.8.1	Bind GitHub WebHooks to actions
2015-01-14	django-theming 1.0	Django application, implement theming concept, flexible and configurable. Allow theming for host url.
2015-01-14	btdb_app 0.1	A flexible database abstraction layer for bit-torrent and uploaded
2015-01-14	swalow 1.0.0	Swallow for data transformation
2015-01-14	salt 0.2.4	Saltalive CLI - Docker hosting
2015-01-14	openid-provider-pebble 0.8	Pebble fork of django_openid_provider
2015-01-14	pygments-ansi-term 0.2.0	Just another colorizer test for my entertainment
2015-01-14	foreman 0.3.0	F-Credit Score Test
2015-01-14	logosyntax 0.1-0	logging handler collection
2015-01-14	wordpress2zimia 1.0	Import your WordPress blog into Zimia
2015-01-14	django-basic-email 0.0.1	Django Basic Email application
2015-01-14	python-apt 0.9.49.3	Ubuntu's package management
2015-01-14	gandi_django 0.12	Gandi command line interface
2015-01-14	firm_web 0.4.3	Frontend Web Application for Fedora Notifications
2015-01-14	pyannote.algorithms 0.2.1	PyAnnote algorithms
2015-01-14	firm.consumer 0.4.3	Backend worker daemon for Fedora notifications
 - Right Sidebar (Not Logged In):**
 - Register
 - Lost Login?
 - Use ClientID
 - Status**: Nothing to report

Installation des paquets

- ▶ A la base **distutils**, ne gère pas les dépendances : `python setup.py`
- ▶ **setuptools** : introduit la commande 'easy_install' qui opère sur de fichiers 'egg': `easy_install example.egg`
- ▶ setuptools a généré **distribute** qui gère les dépendances.
- ▶ **pip** : remplace 'easy_install' : "`pip install paquetExample`"

Outline

Introduction

Description du Langage

Description des paquets scientifiques

Distributions et Environnements de travail

Conclusion

Quelques Paquets et Outils Scientifiques

- ▶ SciPy : scientific python
 - ▶ Numpy
 - ▶ SciPy library
 - ▶ Matplotlib
 - ▶ IPython
- ▶ Mayavi : objets 3D avancés
- ▶ Scikit-learn : machine learning.
- ▶ ...

SciPy

► <http://www.scipy.org/>

The screenshot shows the SciPy.org homepage as it would appear in a web browser. The header features the SciPy logo and navigation links for "Install", "Getting Started", "Documentation", "Report Bugs", and "Blogs". A sidebar on the right contains links to "About SciPy", "Install", "Getting Started", "Documentation", "Bug Reports", "Topical Software", "Citing", "Cookbook", "SciPy Central", "Wiki", "SciPy Conferences", "Blogs", and "NumFOCUS". At the bottom, there's a section for "CORE PACKAGES" listing "Numpy" and "SciPy library". The main content area describes SciPy as a Python-based ecosystem for mathematics, science, and engineering, and lists several core packages with their logos and descriptions: NumPy (Base N-dimensional array package), SciPy library (Fundamental library for scientific computing), Matplotlib (Comprehensive 2D Plotting), IP[y]: (IPython Enhanced Interactive Console), Sympy (Symbolic mathematics), and pandas (Data structures & analysis).

www.scipy.org

SciPy.org — SciPy.org

SciPy.org

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Install Getting Started Documentation Report Bugs Blogs

SciPy (pronounced "Sigh Pie") is a Python-based ecosystem of open-source software for mathematics, science, and engineering. In particular, these are some of the core packages:

 NumPy Base N-dimensional array package	 SciPy library Fundamental library for scientific computing
 Matplotlib Comprehensive 2D Plotting	 IP[y]: IPython Enhanced Interactive Console
 Sympy Symbolic mathematics	 pandas Data structures & analysis

About SciPy
Install
Getting Started
Documentation
Bug Reports
Topical Software
Citing
Cookbook
SciPy Central
Wiki
SciPy Conferences
Blogs
NumFOCUS

CORE PACKAGES:
Numpy
SciPy library

Numpy

- ▶  NumPy <http://www.numpy.org>
- ▶ *NumPy is the fundamental package for scientific computing with Python*

```
>>> import numpy
>>> help(numpy)

Help on package numpy:

NAME
    numpy

FILE
    /Users/becqg/Library/Enthought/Canopy_64bit/User/lib/python2.7/site-packages
    /numpy/__init__.py

DESCRIPTION
    NumPy
    =====

    Provides
        1. An array object of arbitrary homogeneous items
        2. Fast mathematical operations over arrays
        3. Linear Algebra, Fourier Transforms, Random Number Generation
    ...

...
```

N-dimensional array Object

- ▶ N-dimensional array : ndarray
- ▶ Création d'un tableau vide et réservation de l'espace (empty)
- ▶ Accès aux éléments : $A[i, j, \dots]$
- ▶ indices de 0 à $n - 1$
- ▶ indices négatifs de $-n$ à -1

```
>>> A = numpy.empty((2, 2))
>>> print(A)
[[ -1.28822975e-231    2.68678092e+154]
 [  2.24497156e-314    2.24499315e-314]]
>>> A[0, 0] = 1
>>> A[1, 0] = 2
>>> A[0, 1] = 11
>>> A[1, 1] = 12
>>> print(A)
[[ 1.   2.]
 [ 11.  12.]]
>>> type(A)
<type 'numpy.ndarray'>
>>> A[-1, -2] = 11
```

N-dimensional array Object

- ▶ Rappel : accès aux propriétés et méthodes (dir)

```
>>> dir(A)
['T', ..., 'all', 'any', 'argmax', 'argmin', 'argpartition', 'argsort', 'astype',
'base', 'byteswap', 'choose', 'clip', 'compress', 'conj', 'conjugate', 'copy',
'ctypes', 'cumprod', 'cumsum', 'data', 'diagonal', 'dot', 'dtype', 'dump',
'dumps', 'fill', 'flags', 'flat', 'flatten', 'getfield', 'imag', 'item',
'itemset', 'itemsize', 'max', 'mean', 'min', 'nbytes', 'ndim', 'newbyteorder',
'nonzero', 'partition', 'prod', 'ptp', 'put', 'ravel', 'real', 'repeat',
'reshape', 'resize', 'round', 'searchsorted', 'setfield', 'setflags', 'shape',
'size', 'sort', 'squeeze', 'std', 'strides', 'sum', 'swapaxes', 'take',
'tofile', 'tolist', 'tostring', 'trace', 'transpose', 'var', 'view']
```

N-dimensional array Object

Attributs sur la forme du tableau

- ▶ Forme du tableau (`shape`), c'est un tuple.
- ▶ Nombre de dimension (`ndim`)
- ▶ Type des éléments (`dtype`)
- ▶ Taille du tableau (`size`), c'est le nombre de cellules totales.

```
>>> A.shape  
(2, 2)  
>>> (nRow, nCol) = A.shape  
>>> nRow = A.shape[0]  
>>> nCol = A.shape[1]  
>>> A.ndim  
2  
>>> A.dtype  
dtype('float64')  
>>> A.size  
4
```

N-dimensional array Object

Changement de forme

- ▶ Pour changer la forme (reshape)
- ▶ Transposition (T)

```
>>> B = A.reshape((4, 1))
array([[ 1.],
       [ 2.],
       [11.],
       [12.]])
>>> B.ndim
2
>>> B.size
4
>>> B.T
array([[ 1.,   2.,  11.,  12.]])
```

N-dimensional array Object

Copie de tableaux

- ▶ Les éléments de B sont les mêmes que ceux de A, seule la forme change.
- ▶ Si on veut une copie (copy)

```
>>> B[0, 0] = 21
>>> print(A)
[[ 21.   2.]
 [ 11.  12.]]
>>> B[1, 0]
>>> C = A.copy()
>>> C[0, 0] = 31
>>> print(A[0,0], C[0,0])
(21.0, 31.0)
```

N-dimensional array Object

Création de tableaux

- ▶ tableau vide et réservation de l'espace (empty)
- ▶ initialisation à zeros (zeros)
- ▶ initialisation avec des uns (ones)
- ▶ tableau identité (eye) avec la dimension.
- ▶ à partir de listes (array)
- ▶ suivant une étendue (arange)

```
>>> A = numpy.zeros((2, 4))
>>> print(A)
[[ 0.  0.  0.  0.]
 [ 0.  0.  0.  0.]]
>>> A = numpy.ones((3, 2))
>>> print(A)
[[ 1.  1.]
 [ 1.  1.]
 [ 1.  1.]]
>>> A = numpy.eye(2)
>>> print(A)
[[ 1.  0.]
 [ 0.  1.]]
>>> A = numpy.array([[1, 2], [11, 12]])
>>> print(A)
[[ 1  2]
 [11 12]]
>>> print(numpy.arange(0.5, 1.7, 0.1))
[ 0.5  0.6  0.7  0.8  0.9  1.   1.1  1.2  1.3  1.4  1.5  1.6]
```

N-dimensional array Object

Types

- ▶ Définition du type à la création
- ▶ Changement de type (astype)
- ▶ Multiplication ou addition avec un scalaire typé.

```
>>> A = numpy.array([[1, 2], [11, 12]])
>>> print(A.dtype)
int64
>>> A = numpy.array([[1., 2], [11, 12]])
>>> print(A.dtype)
float64
>>> A = numpy.array([[1, 2], [11, 12]], dtype="float")
>>> print(A.dtype)
float64
>>> A = A.astype("complex")
>>> print(A)
[[ 1.+0.j  2.+0.j]
 [ 11.+0.j 12.+0.j]]
>>> A = numpy.array([[1, 2], [11, 12]]) * 1.
>>> print(A.dtype)
float64
```

N-dimensional array Object

Additions, soustractions, multiplications sur les tableaux

- ▶ Addition, soustraction de matrices ou d'un scalaire (+, -)
- ▶ Multiplication par un scalaire (*)
- ▶ Produit élément par élément (*)

```
>>> A = numpy.array([[1, 2], [11, 12]])
>>> B = numpy.array([[3, 4], [13, 14]])
>>> print(A + 10)
[[ 11.   12.]
 [ 21.   22.]]
>>> print(A + B)
[[ 4.   6.]
 [ 24.  26.]]
>>> print(A * 10)
[[ 10.   20.]
 [ 110.  120.]]
>>> print(A * B)
[[   3.    8.]
 [ 143.  168.]]
>>> C = numpy.ones((10, ))
>>> print(A * C)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: operands could not be broadcast together with shapes (2,2) (10)
```

N-dimensional array Object

Produit scalaire

- ▶ Produit scalaire (dot)
- ▶ See also numpy.dot : en général, pour chaque méthode associée à un ndarray, il existe une fonction équivalente dans numpy.

```
>>> A = numpy.array([[1, 2], [11, 12]])
>>> B = numpy.array([[3, 4], [13, 14]])
>>> print(A.dot(B))
[[ 29.   32.]
 [189.  212.]]
>>> print(numpy.dot(A, B))
[[ 29.   32.]
 [189.  212.]]
>>> C = numpy.ones((10, ))
>>> print(A.dot(C))
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
ValueError: matrices are not aligned
>>>
```

N-dimensional array Object

Division

- ▶ Division par un scalaire (/)
- ▶ Division éléments par éléments (/)
- ▶ Attention au type en Python 2.7 !

```
>>> A = numpy.array([[1, 2], [11, 12]])
>>> B = numpy.array([[3, 4], [13, 14]])
>>> print(A / 2)
[[0 1]
 [5 6]]
>>> print(A / B)
[[0 0]
 [0 0]]
>>> print(A / B.astype("float"))
[[ 0.33333333  0.5        ]
 [ 0.84615385  0.85714286]]
```

N-dimensional array Object

Autres méthodes

- ▶ max, min, sum, mean, std, cumsum, cumprod ... sur tous les éléments ou sur une dimension particulière (kwarg axis).

```
>>> A = numpy.ones((2, 3, 4))
>>> print(A)
[[[ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]]

[[ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]]]
>>> print(A.cumsum())
[ 1.  2.  3.  4.  5.  6.
 7.  8.  9.  10.  11.  12.  13.
 14.  15.
 16.  17.  18.  19.  20.  21.  22.
 23.  24.]
>>> print(A.cumsum(axis=0))
[[[ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]
 [ 1.  1.  1.  1.]]

[[ 2.  2.  2.  2.]
 [ 2.  2.  2.  2.]
 [ 2.  2.  2.  2.]]]
```

```
>>> print(A.cumsum(axis=1))
[[[ 1.  1.  1.  1.]
 [ 2.  2.  2.  2.]
 [ 3.  3.  3.  3.]]

[[ 1.  1.  1.  1.]
 [ 2.  2.  2.  2.]
 [ 3.  3.  3.  3.]]]
>>> print(A.cumsum(2))
[[[ 1.  2.  3.  4.]
 [ 1.  2.  3.  4.]
 [ 1.  2.  3.  4.]]

[[ 1.  2.  3.  4.]
 [ 1.  2.  3.  4.]
 [ 1.  2.  3.  4.]]]
```

N-dimensional array Object

Sélection de sous-tableaux

- ▶ découpage, slicing, comme pour les séquences.

```
>>> A = numpy.array([[1, 2, 3, 4], [11, 12, 13, 14]])  
>>> print(A)  
[[ 1  2  3  4]  
 [11 12 13 14]]  
>>> print(A[1, :])  
[11 12 13 14]  
>>> print(A[:, 1:3])  
[[ 2  3]  
 [12 13]]
```

N-dimensional array Object

Sélection de sous-tableaux

- ▶ Comparaison et opérateurs logiques
- ▶ Opérations logiques pour sélectionner des éléments (masking)
- ▶ Récupérer les indices (where)

```
>>> A = numpy.array([[1, 2, 3, 4], [11, 12, 13, 14]])  
>>> print(A)  
[[ 1  2  3  4]  
 [11 12 13 14]]  
>>> B = A > 2  
>>> print(B)  
[[False False  True  True]  
 [ True  True  True  True]]  
>>> print(A[B])  
[ 3  4 11 12 13 14]  
>>> indices = numpy.where(B)  
>>> print(indices[0])  
array([0, 0, 1, 1, 1, 1])  
>>> print(indices[1])  
array([2, 3, 0, 1, 2, 3])  
>>> (i, j) = numpy.where(A > 2)
```

N-dimensional array Object

Concaténations

- ▶ Concaténation horizontale (hstack)
- ▶ Concaténation verticale (vstack)
- ▶ concatenate (concatenate, kwarg axis)

```
>>> A = numpy.array([[1, 2], [11, 12]])
>>> B = numpy.array([[3, 4], [13, 14]])
>>> C = numpy.vstack((A, B))
>>> print(C)
[[ 1  2]
 [11 12]
 [ 3  4]
 [13 14]]
>>> D = numpy.hstack((A, B, A, A))
>>> print(D)
[[ 1  2  3  4  1  2  1  2]
 [11 12 13 14 11 12 11 12]]
>>> E = numpy.concatenate((A, B, A, A), axis=1)
>>> print(E)
[[ 1  2  3  4  1  2  1  2]
 [11 12 13 14 11 12 11 12]]
```

N-dimensional array Object

Structured Arrays

- ▶ Possibilité de mettre des éléments de types différents.
- ▶ Possibilité de tableaux structurés ...

```
>>> A = numpy.array([["a", 1], ["b", 2]], dtype="object")
>>> print(A)
[['a', 1]
 ['b', 2]]
>>> print(A.dtype)
object

>>> A = numpy.array([(1, "abc"), (2, "def")], dtype=[("index", "int"),
("name", "S8")])
>>> print(A)
[(1, 'abc') (2, 'def')]
>>> A["index"]
array([1, 2])
>>> A["name"]
array(['abc', 'def'],
      dtype='|S8')
```

Sauvegarde et lecture de données

- ▶ Enregistrement d'un tableau (save) dans un fichier ".npy"
- ▶ Enregistrement compressé de plusieurs tableaux (savez) au format ".npz"
- ▶ Lecture (load) des fichiers ".npy", ".npz"

```
>>> A = numpy.array([[1, 2], [11, 12]])
>>> numpy.save("save_A", A)
>>> del(A)
>>> A = numpy.load("save_A.npy")
>>> print(A)
[[ 1  2]
 [11 12]]
>>> A = numpy.array([[1, 2], [11, 12]])
>>> B = numpy.array([[21, 22], [31, 32]])
>>> numpy.savez("save_AB", tab1=A, B=B)
>>> del(A, B)
>>> data = numpy.load("save_AB.npz")
>>> print(data["tab1"])
[[ 1  2]
 [11 12]]
>>> print(data["B"])
[[21 22]
 [31 32]]
```

Sauvegarde et lecture de données txt

- ▶ Lecture de fichier texte ".txt" (load ou loadtxt)
- ▶ Enregistrement (savetxt)

```
>>> A = numpy.loadtxt("data.txt")
>>> A
array([[ 1.,   2.,   3.,   4.,   5.],
       [11.,  12.,  13.,  14.,  15.],
       [21.,  22.,  23.,  24.,  25.]])
>>> numpy.savetxt("data.txt", A)
```

Matrix

Définition

- ▶ Classe héritée de ndarray avec ndim = 2.

```
>>> help(numpy.matrix)
class matrix(numpy.ndarray)
|   matrix(data, dtype=None, copy=True)
|
|   Returns a matrix from an array-like object, or from a string of data.
|   A matrix is a specialized 2-D array that retains its 2-D nature
|   through operations. It has certain special operators, such as “*”
|   (matrix multiplication) and “**” (matrix power).
...
...
```

Matrix

Saisie

- ▶ Saisie directe de type ndarray avec des listes imbriquées.
- ▶ Possibilité de saisie type Matlab.

```
>>> A = numpy.matrix([[1, 2], [11, 12]])
>>> print(A)
[[ 1  2]
 [11 12]]
>>> type(A)
<class 'numpy.matrixlib.defmatrix.matrix'>
>>> A = numpy.matrix("[1, 2, 3, 4; 11, 12, 13, 14]")
>>> print(A)
[[ 1  2  3  4]
 [11 12 13 14]]
```

Matrix

Multiplication et exposant

- ▶ Produit de matrices (*)
- ▶ Exposant de matrice (**)

```
>>> A = numpy.matrix([[1, 2], [11, 12]])
>>> B = numpy.matrix([[3, 4], [13, 14]])
>>> print(A * B)
[[ 29   32]
 [189  212]]
>>> print(A ** 2)
[[ 23   26]
 [143  166]]
```

Matrix

Opérateurs matriciels courants

- ▶ Transposition (T)
- ▶ Inversion (I)
- ▶ Opérateur Hermitien (H)

```
>>> A = numpy.matrix([[1, 2], [11, 12]])
>>> print(A)
[[ 1  2]
 [11 12]]
>>> print(A.T)
[[ 1 11]
 [ 2 12]]
>>> print(A.I)
print(A.I)
[[[-1.2  0.2]
 [ 1.1 -0.1]]
>>> B = numpy.matrix([[1, 2+1j], [11+1j, 12]])
>>> print(B)
[[ 1.+0.j  2.+1.j]
 [ 11.+1.j 12.+0.j]]
>>> print(B.H)
[[ 1.-0.j  11.-1.j]
 [ 2.-1.j 12.-0.j]]
```

Autres opérations d'algèbre linéaire

Sous paquet linalg

► Interface vers Lapack (numpy.linalg)

```
>>> help(numpy.linalg)
...
Linear algebra basics:

- norm           Vector or matrix norm
- inv            Inverse of a square matrix
- solve          Solve a linear system of equations
- det             Determinant of a square matrix
- lstsq           Solve linear least-squares problem
- pinv            Pseudo-inverse (Moore-Penrose)...
- matrix_power    Integer power of a square matrix

Eigenvalues and decompositions:

- eig             Eigenvalues and vectors of a square matrix
- eigh            Eigenvalues and eigenvectors of a Hermitian matrix
- eigvals         Eigenvalues of a square matrix
- eigvalsh        Eigenvalues of a Hermitian matrix
- qr              QR decomposition of a matrix
- svd             Singular value decomposition of a matrix
- cholesky        Cholesky decomposition of a matrix

Tensor operations:

- tensorsolve     Solve a linear tensor equation
- tensorinv       Calculate an inverse of a tensor
...
```

Autres paquets de numpy

```
>>> help(numpy)
...
doc
    Topical documentation on broadcasting, indexing, etc.
lib
    Basic functions used by several sub-packages.
random
    Core Random Tools
linalg
    Core Linear Algebra Tools
fft
    Core FFT routines
polynomial
    Polynomial tools
testing
    Numpy testing tools
f2py
    Fortran to Python Interface Generator.
distutils
    Enhancements to distutils with support for
        Fortran compilers support and more.
...
...
```

Autres paquets de numpy

Random

- ▶ Sous paquet random : générateurs de nombres aléatoires.

```
>>> numpy.random.seed(0)
>>> A = numpy.random.randn(2, 3, 4)
>>> print(A)
[[[ 1.76405235  0.40015721  0.97873798  2.2408932 ]
 [ 1.86755799 -0.97727788  0.95008842 -0.15135721]
 [-0.10321885  0.4105985   0.14404357  1.45427351]]

 [[ 0.76103773  0.12167502  0.44386323  0.33367433]
 [ 1.49407907 -0.20515826  0.3130677   -0.85409574]
 [-2.55298982  0.6536186   0.8644362   -0.74216502]]]
```

Scipy library

Librairie scientifique

- ▶  <http://www.scipy.org/scipylib/index.html>
- ▶ *It provides many user-friendly and efficient numerical routines such as routines for numerical integration and optimization.*

```
>>> import scipy
>>> help(scipy)
...
cluster                               --- Vector Quantization / Kmeans
fftpack                                --- Discrete Fourier Transform algorithms
integrate                             --- Integration routines
interpolate                           --- Interpolation Tools
io                                     --- Data input and output
lib                                    --- Python wrappers to external libraries
lib.lapack                            --- Wrappers to LAPACK library
linalg                                 --- Linear algebra routines
misc                                  --- Various utilities that don't have
                                         another home.
ndimage                                --- n-dimensional image package
odr                                    --- Orthogonal Distance Regression
optimize                               --- Optimization Tools
signal                                 --- Signal Processing Tools
sparse                                 --- Sparse Matrices
sparse.linalg                         --- Sparse Linear Algebra
...
...
```

Scipy

- ▶ Optimisation, Intégration, Interpolation, Algèbre linéaire, Algèbre linaire creuse, Signal, Image, Statistiques, Fonctions spéciales (Γ , ψ)...

```
...  
sparse.linalg.dsolve      --- Linear Solvers  
sparse.linalg.dsolve.umfpack --- :Interface to the UMFPACK library:  
                                Conjugate Gradient Method (LOBPCG)  
sparse.linalg.eigen.lobpcg --- Locally Optimal Block Preconditioned  
                                Conjugate Gradient Method (LOBPCG) [*]  
special                   --- Airy Functions [*]  
lib.blas                  --- Wrappers to BLAS library [*]  
sparse.linalg.eigen        --- Sparse Eigenvalue Solvers [*]  
stats                     --- Statistical Functions [*]  
lib                      --- Python wrappers to external libraries  
                            [*]  
lib.lapack                --- Wrappers to LAPACK library [*]  
integrate                 --- Integration routines [*]  
ndimage                   --- n-dimensional image package [*]  
linalg                    --- Linear algebra routines [*]  
spatial                   --- Spatial data structures and algorithms  
special                   --- Airy Functions  
stats                     --- Statistical Functions  
...  
...
```

Scipy

lecture de fichiers Matlab

- ▶ Exemple, lectures de fichiers Matlab dans le subpackage io (scipy.io)

```
>>> import scipy.io  
>>> data = scipy.io.loadmat('file.mat')
```

Matplotlib

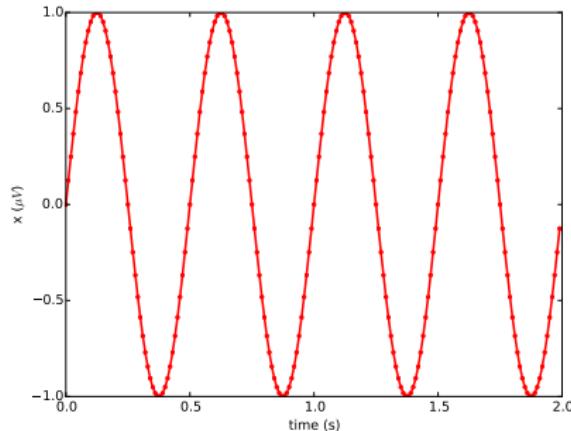
- ▶  : <http://www.matplotlib.org>
- ▶ *matplotlib is a python 2D plotting library which produces publication quality figures in a variety of hardcopy formats and interactive environments across platforms.*
- ▶ Contient des classes : programmation orientée objets avec différents backends pour différentes interfaces graphiques, graphical user interfaces (GUI) : agg, gtk, qt, svg, ps, pdf...
- ▶ Contient des procédures pour faciliter l'accès à ces classes : matlab style.

Matplotlib

pyplot

- ▶ Fonctions procédurales dans le sous-paquet pyplot
(`matplotlib.pyplot`)

```
>>> import matplotlib.pyplot
>>> t = numpy.arange(0, 10, 0.01)
>>> x = numpy.sin(2 * numpy.pi * 3 * t)
>>> matplotlib.pyplot.plot(t, x)
>>> matplotlib.pyplot.xlabel("time (s)")
>>> matplotlib.pyplot.ylabel("x ($\mu$ V$)")
>>> matplotlib.pyplot.show()
```



Matplotlib

Saving figures

- ▶ Sauvegarde manuelle à partir de la fenêtre ouverte sur l'icône save.
- ▶ sauvegarde en ligne de commande (savefig) sans passage par un affichage à l'écran.

```
...  
->>> matplotlib.pyplot.ylabel("x ($\mu V$)")  
->>> # matplotlib.pyplot.show()  
->>> matplotlib.pyplot.savefig("./sinus.ps")  
->>> matplotlib.pyplot.savefig("./sinus.pdf")  
->>> matplotlib.pyplot.savefig("./sinus.svg")  
->>> matplotlib.pyplot.savefig("./sinus.tiff")  
->>> matplotlib.pyplot.savefig("./sinus.png")  
->>> matplotlib.pyplot.savefig("./sinus.jpg")
```

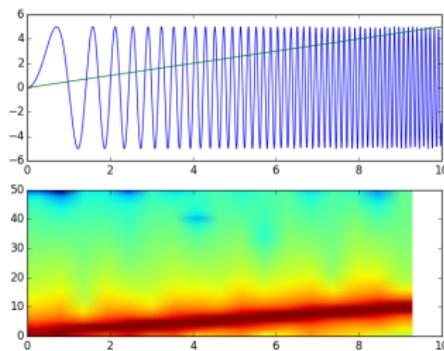
Matplotlib

Pylab

- ▶ Fonctions à la Matlab dans le sous-paquet pylab (matplotlib.pyplot)
- ▶ Beaucoup de fonctions sous formes abrégées . . .

```
>>> import matplotlib.pyplot as mpl
>>> len(dir(mpl))
955

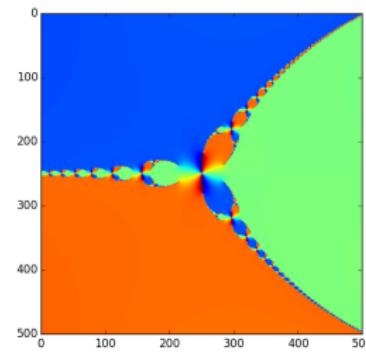
>>> from pylab import *
>>> t = arange(0, 10, 0.01)
>>> f = arange(0, 5, 0.005)
>>> x = sin(2 * pi * f * t)
>>> subplot(2, 1, 1)
>>> plot(t, x * 5)
>>> plot(t, f)
>>> subplot(2, 1, 2)
>>> res = specgram(x, NFFT=64,
... Fs=100, noverlap=8)
>>> show()
```



Matplotlib

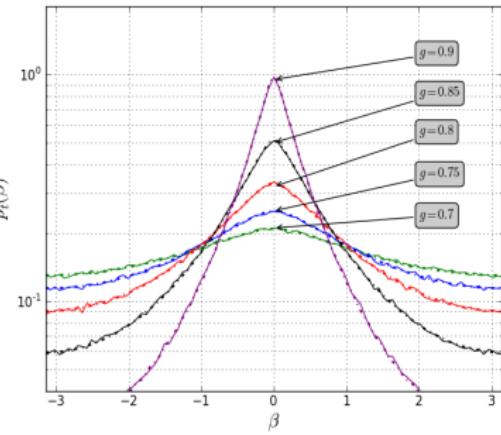
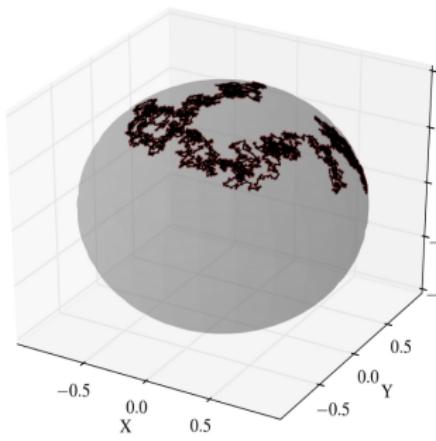
Pylab

```
>>> (X, Y) = meshgrid(linspace(-2, 2,
... 500), linspace(-2, 2, 500))
>>> Z = X + Y * 1j
>>> for k in range(76):
...     Z -= (Z / 3 - 1) / (3 * Z ** 2)
>>> close("all")
>>> imshow(angle(Z))
>>> # savefig('/MonChemin/Lenom.pdf')
>>> show()
```



Matplotlib

Exemples de Nicolas Le Bihan



IPython

- ▶ IP[y]: IPython
Interactive Computing

<http://www.scipy.org/scipylib/index.html>

- ▶ Enhanced python console
- ▶ Attention, ce n'est pas un paquet mais une console améliorée !
- ▶ Accessible à partir d'un terminal (ipython)
- ▶ Complétion automatique avec la touche tab
- ▶ Fonctions magiques (magic)

```
$ ipython
```

```
Python 2.7.3 | 64-bit | (default, Jun 14 2013, 18:17:36)
Type "copyright", "credits" or "license" for more information.
```

```
IPython 2.2.0 -- An enhanced Interactive Python.
?           -> Introduction and overview of IPython's features.
%quickref -> Quick reference.
help       -> Python's own help system.
object?    -> Details about 'object', use 'object??' for extra details.
```

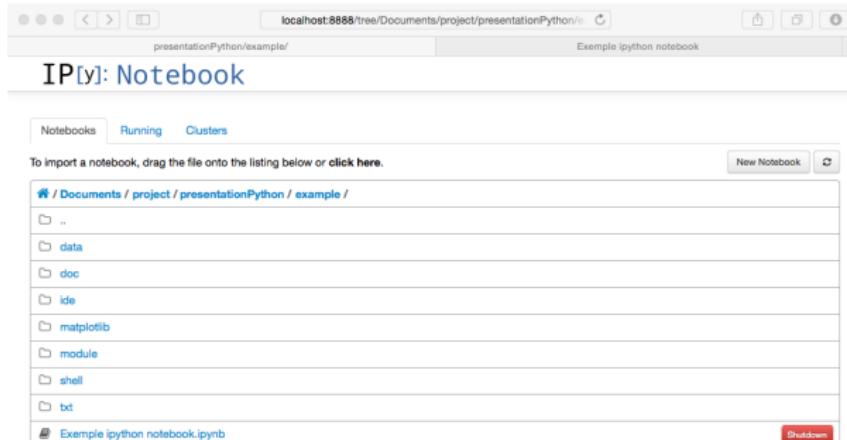
```
In [1]: %pylab
Using matplotlib backend: MacOSX
Populating the interactive namespace from numpy and matplotlib
```

```
In [2]:
```

IPython

ipython notebook

- ▶ Accessible à partir d'un terminal (ipython notebook)
- ▶ Ouverture et création de notebooks (*.pynb)



IPython

ipython notebook

- ▶ Les cellules exécutent du code ou formatent du texte
- ▶ Chargement des fonctions pylab avec affichage dans le notebook : %pylab inline

The screenshot shows the IPython Notebook interface running in a browser window. The title bar indicates the URL is localhost:8888/notebooks/Documents/project/pre/presentationPython/example/ and the tab title is "Exemple ipython notebook (autosaved)". The main area displays a notebook titled "Exemple de notebook". It contains several code cells:

- In [1]: `%pylab inline`
Populating the interactive namespace from numpy and matplotlib
- In [6]: `import sys
sys.path.append("./Users/becqg/Documents/project/dinfo/src/python/dinfo")`
- In [8]: `import dinfo_c, model`
- In [39]: `help(model.GlassMackey)`
Help on function GlassMackey in module model:

GlassMackey(nObs, epsilonX, epsilonY, alpha)
 Simulate samples from equations based on a Glass Mackey model
 used in Amblard et al., A Gaussian Process Regression..., 2012

Below the code cells, there are sections for "Syntax", "Input", "Output", and "Definition" which provide detailed information about the GlassMackey function.

IPython

ipython notebook

- ▶ Saisie et affichage en HTML et LaTeX, entre autres.

The screenshot shows a web-based IPython Notebook interface. At the top, there's a browser-like header with tabs for 'localhost:8888/notebooks/Documents/project/pr...' and 'Exemple ipython notebook (autosaved)'. Below it is the notebook's header with tabs for File, Edit, View, Insert, Cell, Kernel, and Help. A toolbar below the header includes icons for file operations like Open, Save, and Print, along with a 'Cell Toolbar' dropdown set to 'None'.

The main content area displays a cell containing text and two equations:

The system is given by this equation:

$$\begin{cases} x_t = x_{t-1} - 0.4 \left(x_{t-1} - \frac{2x_{t-4}}{1 + x_{t-4}^{10}} \right) y_{t-5} + 0.3 y_{t-3} + \epsilon_{x,t} \\ y_t = y_{t-1} - 0.4 \left(y_{t-1} - \frac{2y_{t-2}}{1 + y_{t-2}^{10}} \right) + \alpha x_{t-2} + \epsilon_{y,t} \end{cases}$$

Below the equations are two code cells:

```
In [32]: nObs = 10000  
(x, y) = model.GlassMackey(nObs, 0.03 * randn(nObs), 0.02 * randn(nObs), 0.1)
```

```
In [33]: plot(x, y, '.')
```

The output of the second cell is:

```
Out[33]: <matplotlib.lines.Line2D at 0x1130e7810>
```

Below the plot is a scatter plot of blue points showing three distinct clusters.

Further down, another code cell is shown:

```
In [36]: mi_xy = dinfo_c.mi(x, y, "Frenzel", (20, "Euclidean"))
```

```
In [37]: print(mi_xy)
```

The output of the last cell is:

```
0.876832495196
```

At the bottom, there's a navigation bar with icons for back, forward, search, and other notebook functions.

Mayavi

- ▶ <http://docs.enthought.com/mayavi/mayavi>
- ▶ <https://github.com/enthought/mayavi>
- ▶ Manipulation des objets 3D améliorée (objet vtk).

The screenshot shows a web browser displaying the Mayavi 4.4.0 documentation. The title bar reads "Mayavi: 3D scientific data visualization and plotting in Python — mayavi 4.4.0 documentation". The main content area features the Mayavi logo and the heading "Mayavi: 3D scientific data visualization and plotting in Python". Below this, there are four main sections: "Using the Mayavi application" (with a subtext about understanding and using the interactive application), "Python scripting for 3D plotting" (with a subtext about the simple scripting API), "Gallery and examples" (with a subtext about an example gallery of visualizations and their generating code), and a welcome message at the bottom. The left sidebar contains links for "Next topic", "This Page", "Quick search", and a search bar. At the very bottom, there are navigation icons for the presentation slide.

Mayavi: 3D scientific data visualization and plotting in Python — mayavi 4.4.0 documentation

next | index

Mayavi 4.4.0 documentation »

Mayavi: 3D scientific data visualization and plotting in Python

Using the Mayavi application
Understanding and using the Mayavi interactive application

Python scripting for 3D plotting
The simple scripting API to Mayavi

Gallery and examples
Example gallery of visualizations, with the Python code that generates them

Welcome, this is the user guide for Mayavi, a application and library for **interactive scientific data visualization and 3D plotting in Python**.

Next | Index

Mayavi

Next topic

An overview of Mayavi

This Page

Show Source

Quick search

Enter search terms or a module, class or function name.

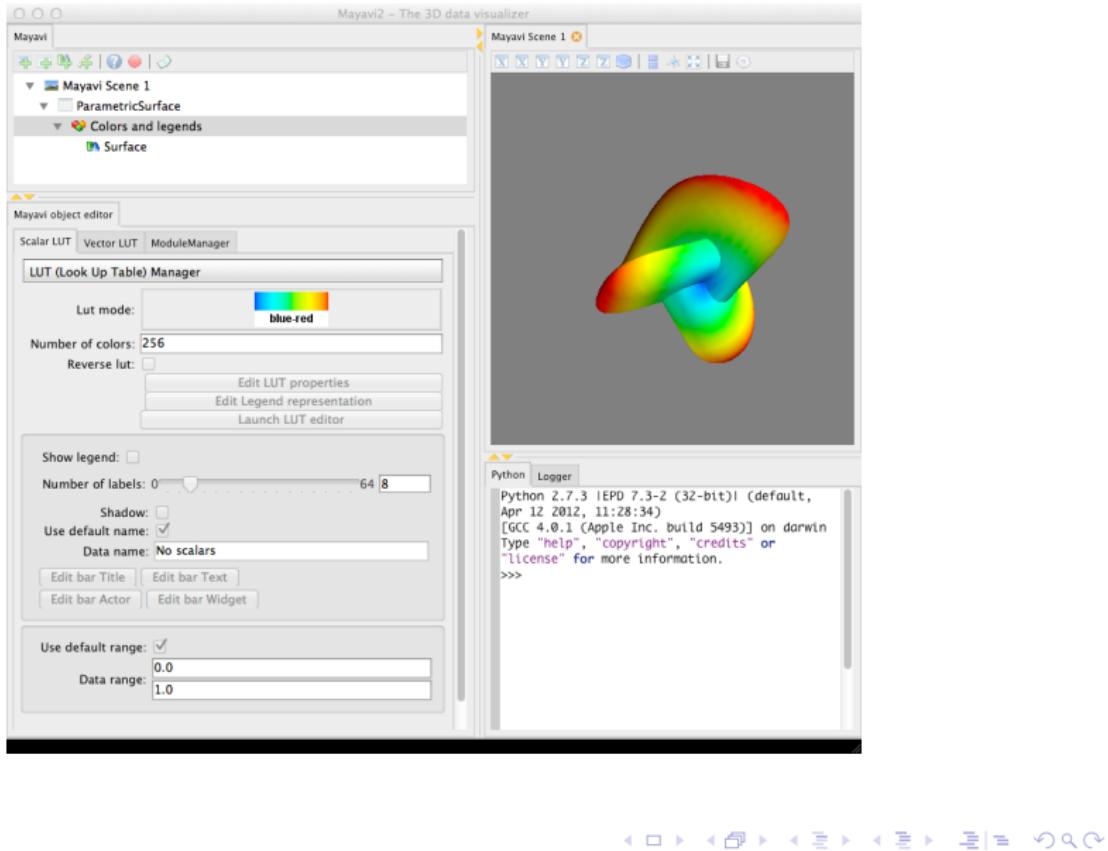
Google Search

only search Mayavi documentation

Go

Navigation icons: back, forward, search, etc.

Mayavi



Mayavi

```
import mayavi.engine
```

- ▶ Dans une console Python : import mayavi. ...

```
>>> from mayavi.api import Engine
>>> engine = Engine()
>>> engine.start()
>>> engine.new_scene()
>>> from mayavi.sources.parametric_surface import ParametricSurface
>>> parametric_surface1 = ParametricSurface()
>>> scene = engine.scenes[0]
>>> engine.add_source(parametric_surface1, scene)
>>> from mayavi.modules.surface import Surface
>>> surface1 = Surface()
>>> engine.add_filter(surface1, parametric_surface1)
```

Scikit-learn

- ▶ <http://scikit-learn.org/>
- ▶ <https://github.com/scikit-learn/scikit-learn>

The screenshot shows the official scikit-learn documentation website. At the top, there's a navigation bar with links for Home, Installation, Documentation, Examples, and a search bar. A 'GitHub' button is also present. On the right side, there's a 'Follow me on GitHub' badge.

The main content area features a large blue header with the text "scikit-learn" and "Machine Learning in Python". Below the header, there's a bulleted list of features:

- Simple and efficient tools for data mining and data analysis
- Accessible to everybody, and reusable in various contexts
- Built on NumPy, SciPy, and matplotlib
- Open source, commercially usable - BSD license

The page is divided into several sections with sub-sections and examples:

- Classification**: Identifying to which set of categories a new observation belongs to. Applications: Spam detection, Image recognition. Algorithms: SVM, nearest neighbors, random forest, ...
- Regression**: Predicting a continuous value for a new example. Applications: Drug response, Stock prices. Algorithms: SVR, ridge regression, Lasso, ...
- Clustering**: Automatic grouping of similar objects into sets. Applications: Customer segmentation, Grouping experiment outcomes. Algorithms: k-Means, spectral clustering, mean-shift, ...
- Dimensionality reduction**: Reducing the number of random variables to consider. Applications: Visualization, Increased efficiency. Algorithms: PCA, feature selection, non-negative matrix factorization.
- Model selection**: Comparing, validating and choosing parameters and models. Goal: Improved accuracy via parameter tuning. Modules: grid search, cross validation, metrics.
- Preprocessing**: Feature extraction and normalization. Application: Transforming input data such as text for use with machine learning algorithms. Modules: preprocessing, feature extraction.

Scikit-learn

Help content

```
>>> import sklearn
>>> help(sklearn)

DESCRIPTION
Machine learning module for Python
=====
sklearn is a Python module integrating classical machine
learning algorithms in the tightly-knit world of scientific Python
packages (numpy, scipy, matplotlib).

It aims to provide simple and efficient solutions to learning problems
that are accessible to everybody and reusable in various contexts:
machine-learning as a versatile tool for science and engineering.

See http://scikit-learn.org for complete documentation.
```

PACKAGE CONTENTS

```
--check_build (package)
_build_utils
_hmmc
_isotonic
base
cluster (package)
covariance (package)
cross_decomposition (package)
cross_validation
datasets (package)
decomposition (package)
dummy
ensemble (package)
externals (package)
```

Scikit-learn

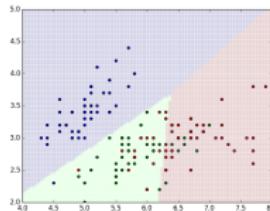
Help content

```
feature_extraction (package)
feature_selection (package)
gaussian_process (package)
grid_search
hmm
isotonic
kernel_approximation
lda
learning_curve
linear_model (package)
kernel_approximation
lda
learning_curve
linear_model (package)
manifold (package)
metrics (package)
mixture (package)
multiclass
naive_bayes
neighbors (package)
neural_network (package)
pipeline
pls
preprocessing (package)
qda
random_projection
semi_supervised (package)
setup
svm (package)
tests (package)
tree (package)
utils (package)
```

Scikit-learn

Exemple de Classifieur : Linear Discriminant Analysis

```
>>> from sklearn.datasets import load_iris
>>> from sklearn.lda import LDA
>>> dic = load_iris()
>>> x = dic["data"]
>>> y = dic["target"]
>>> nClasses = unique(y).size
>>> clf = LDA()
>>> clf.fit(x[:, :2], y)
>>> (mx1, mx2) = meshgrid(linspace(4, 8, 100), linspace(2, 5, 100))
>>> Z = clf.predict(vstack((mx1.flatten().T, mx2.flatten())).T)
>>> pcolor(mx1, mx2, Z.reshape(mx1.shape), alpha=0.1)
>>> colors = ["b", "g", "r"]
>>> for i in range(nClasses):
>>>     scatter(x[y==i, 0], x[y==i, 1], c=colors[i])
>>> axis(xmin=4, xmax=8, ymin=2, ymax=5)
>>> show()
```



Importation de bibliothèques de fonctions écrites en C

Exemple using module ctypes

```
import ctypes
libName = './clz.lib'
libCLZ = ctypes.CDLL(libName)
clz_c = libCLZ.clz
clz_c.restype = ctypes.c_uint
sequence = numpy.ctypeslib.ndpointer(dtype=numpy.int)
clz_c.argtypes = ([sequence, ctypes.c_uint])
# conversion of s into sequence with numpy.asarray
c = clz_c(numpy.asarray(s, dtype='int'), n)
```

Outline

Introduction

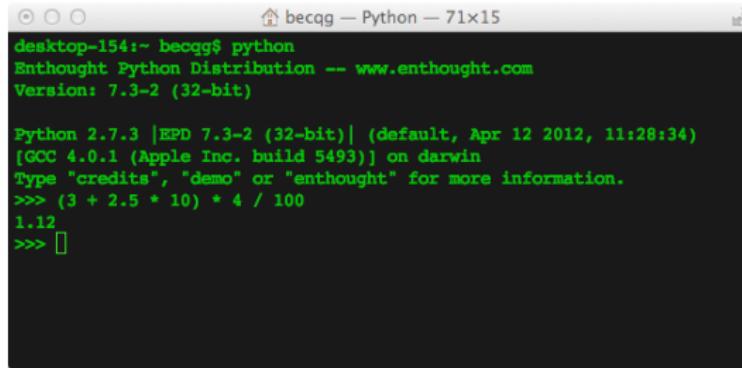
Description du Langage

Description des paquets scientifiques

Distributions et Environnements de travail

Conclusion

- ▶ Python 2.7 ou 3.x téléchargeable sur www.python.org.
- ▶ Livré uniquement avec la bibliothèque standard.
- ▶ Inclus l'interpréteur Python natif accessible à partir de l'environnement système.
- ▶ Parfait pour tester des petits bouts de codes.



A screenshot of a terminal window titled "becqq — Python — 71x15". The window displays the following text:

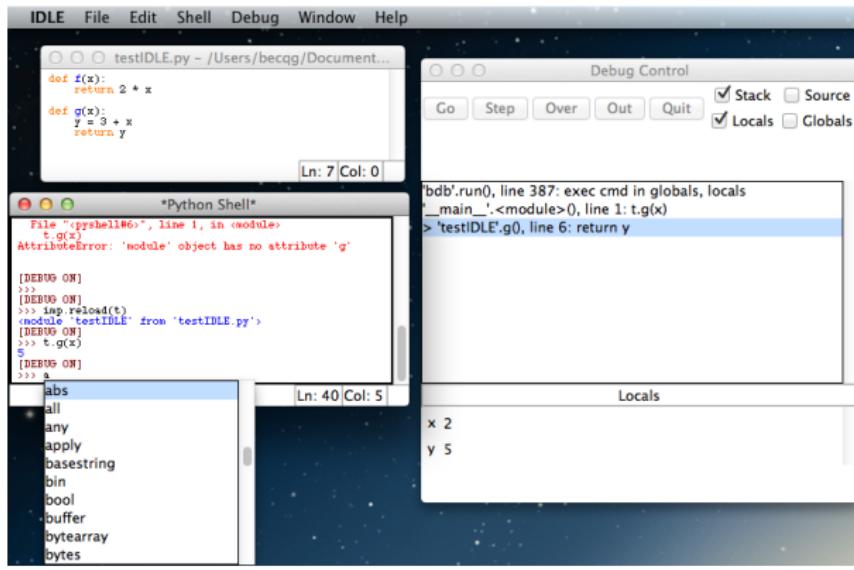
```
desktop-154:~ becqq$ python
Enthought Python Distribution -- www.enthought.com
Version: 7.3-2 (32-bit)

Python 2.7.3 |EPD 7.3-2 (32-bit)| (default, Apr 12 2012, 11:28:34)
[GCC 4.0.1 (Apple Inc. build 5493)] on darwin
Type "credits", "demo" or "enthought" for more information.
>>> (3 + 2.5 * 10) * 4 / 100
1.12
>>> [
```

Python IDLE

official

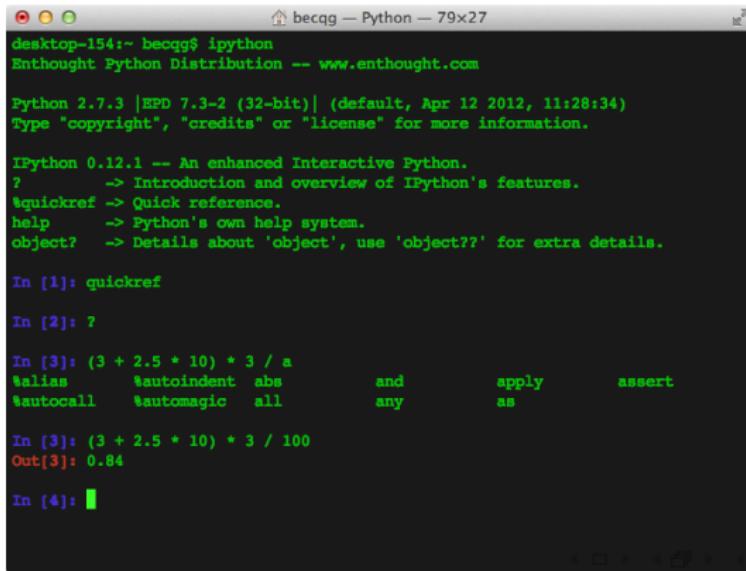
- ▶ Python livré avec un Integrated Development Environment (IDLE) :
 - ▶ Une console Python : coloration automatique, autocomplétion ...
 - ▶ Un éditeur de texte : indentation automatique, coloration syntaxique, debuggeur, ...



IPython

Intro

- ▶ IP[y]: IPython
Interactive Computing IPy: <http://ipython.org>
- ▶ Console interactive accessible via le shell : coloration syntaxique, fonctions magiques, mémorisation des commandes, débugueur, profileur, calculs parallèles ...
- ▶ Plusieurs options cf. 'man ipython' ou 'ipython -help'.



becqq — Python — 79x27

```
desktop-154:~ becqq$ ipython
Enthought Python Distribution -- www.enthought.com

Python 2.7.3 |EPD 7.3-2 (32-bit)| (default, Apr 12 2012, 11:28:34)
Type "copyright", "credits" or "license" for more information.

IPython 0.12.1 -- An enhanced Interactive Python.
?           -> Introduction and overview of IPython's features.
quickref  -> Quick reference.
help       -> Python's own help system.
object?   -> Details about 'object', use 'object??' for extra details.

In [1]: quickref

In [2]: ?

In [3]: (3 + 2.5 * 10) * 3 / a
alias      %autoindent  abs          and         apply      assert
autocall   %automagic   all          any         as

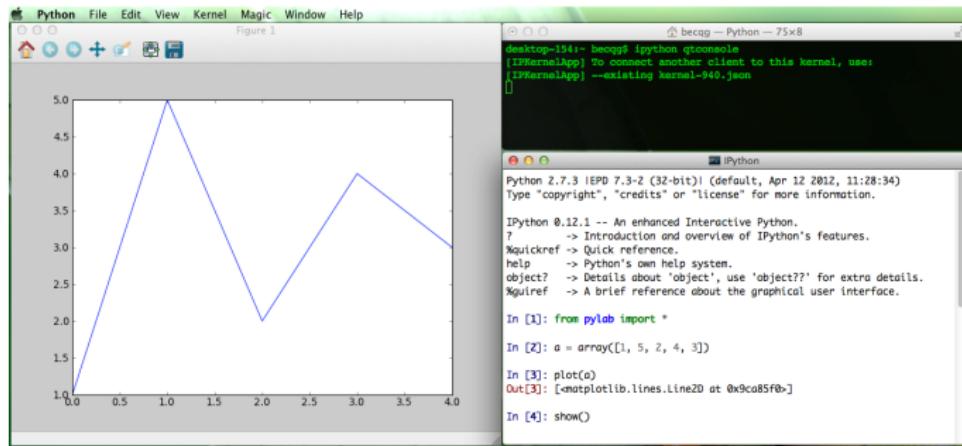
In [3]: (3 + 2.5 * 10) * 3 / 100
Out[3]: 0.84

In [4]: 
```

IPython

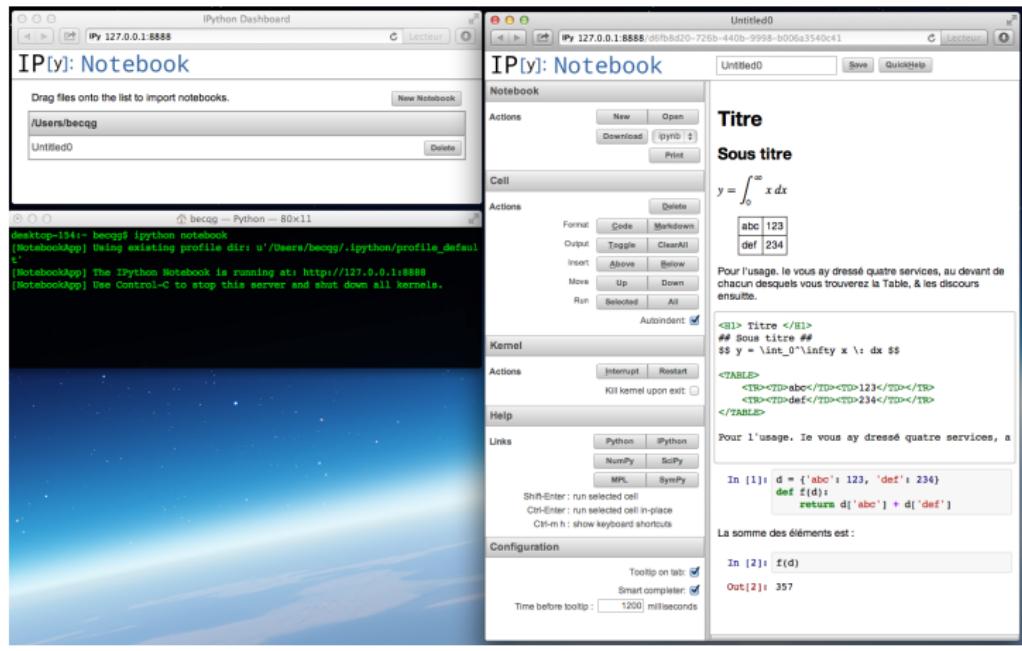
Qtconsole

- ▶ Commande dans le shell : ipython qtconsole
- ▶ Environnement graphique Qt qui permet de tracer des figures via matplotlib ou pylab.
- ▶ Commande directe : ipython qtconsole –pylab



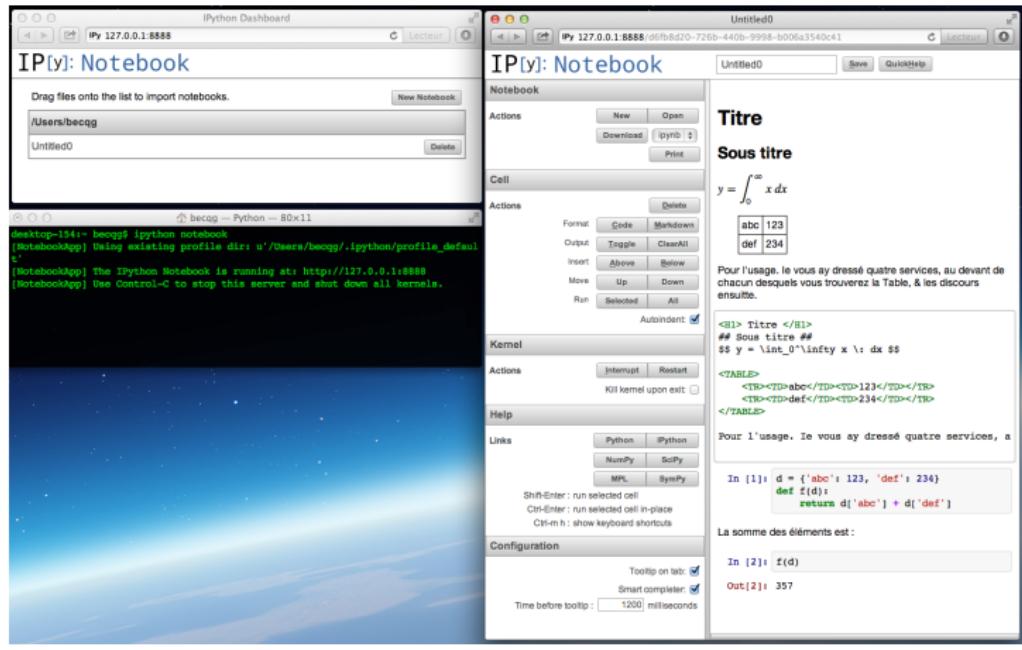
IPython notebook

- ▶ Commande dans le shell : ipython notebook
- ▶ Editeur dans le navigateur HTML, *Web-based interactive computational environment.*



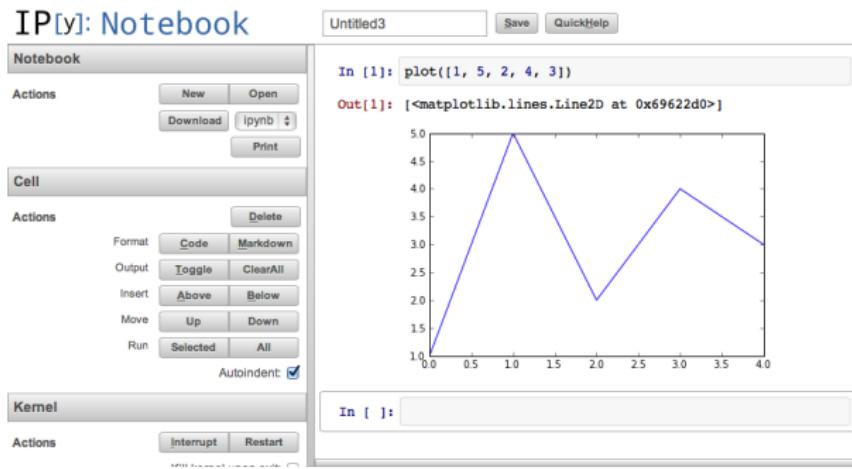
IPython notebook

- ▶ Cellules de codes ou de documentation : *Cell Mode* à la Matlab, *Document-Based Workflow* à la Mathematica.
- ▶ Balisage du texte en LaTeX, HTML ou Markdown.



IPython notebook

- ▶ Commande pour importer pylab et graphique dans l'interface html : 'ipython notebook –pylab inline'
- ▶ Génération de rapports dans le menu 'notebook > action > print' puis impression en pdf pour le navigateur HTML.



Enthought Canopy

- ▶  ENTHOUGHT :

<https://www.enthought.com/products/canopy/>

- ▶ Contient Python et +100 librairies orientées applications scientifiques.
- ▶ Multi-plateformes, *Easy installation and update.*
- ▶ Gratuit pour les étudiants et les universitaires.
- ▶ Anciennement Enthought Python Distribution EPD.
- ▶ QtConsole, iPython.

Enthought Canopy

Welcome to Canopy

Hi guillaume, welcome to Canopy!
Logged in as guillaume.becq@gipsa-lab.grenoble-inp.fr.
Logout.

Editor Package Manager Doc Browser

Available Packages

- abstract_rendering 0.5.1
- agw 0.9.1
- amqp 1.4.5
- anyjson 0.3.3
- appinst 2.1.2
OS abstraction for installing application menus, links and icons
- appscript 1.0.1
- apptools 4.2.1
annotation handling, link technologies

Recent files

- testCanopy.py
- test.py
- ...
test.ipynb
- setup.py

File Browser

Filter: All Supported Files

- becq
- Recent Files
 - testCanopy.py
 - test.py
 - BecqVodaBesan20131...
 - test.ipynb
 - setup.py

testCanopy.py

```
1 a = 1
2 a += 1
3 b = a + 2
4 print(a, b)
5
```

Welcome to Canopy's interactive data-analysis environment!
with pylab-backend set to: qt
Type '?' for more information.

```
In [1]: kcd "/Users/becq/Documents"
/Users/becq/Documents

In [2]: Xrun /Users/becq/Documents/testCanopy.py
2

In [3]: Xrun /Users/becq/Documents/testCanopy.py
(2, 4)
```

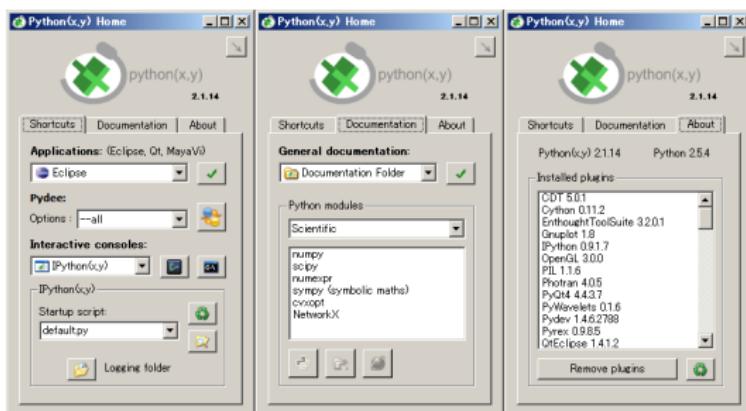
Cursor pos 4 : 11 Python

guillaume becq
CANOPY Need help? Ask experts

~Documents/testCanopy.py

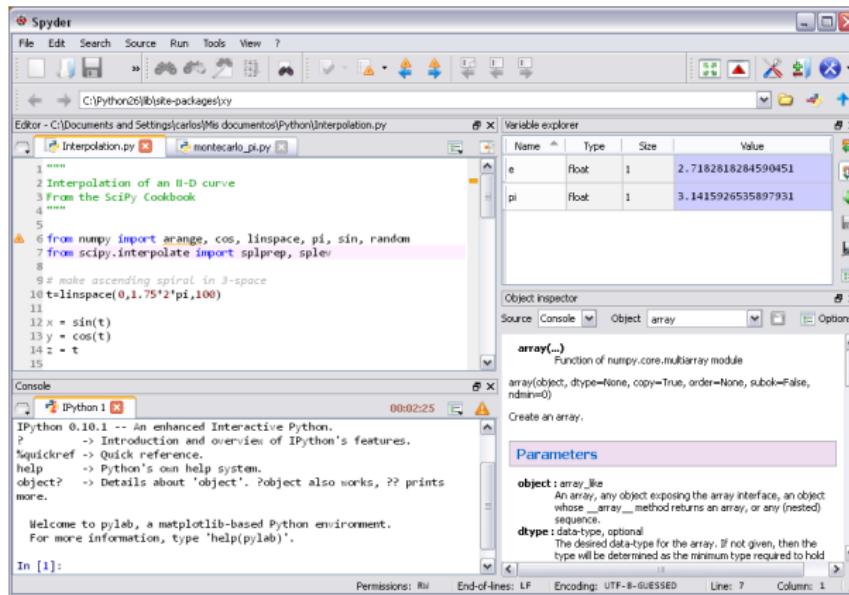
Python(x,y)

- ▶  Python(x,y) : <https://code.google.com/p/pythonxy/>
- ▶ *Python(x,y) is a free scientific and engineering development software for numerical computations, data analysis and data visualization based on Python programming language, Qt graphical user interfaces and Spyder interactive scientific development environment.*
- ▶ Un grand nombre de librairies scientifiques, entre autres.
- ▶ Interface avec Eclipse (IDE principalement pour Java mais aussi Python).



Python(x,y) Spyder

- ▶ Spyder (multiplateforme) : environnement de type Matlab pour Python.



source web

Anaconda

- ▶  <http://continuum.io/downloads>
- ▶  Anaconda

Autres Integrated Development Environment

- ▶ Tout éditeur de texte avec coloration syntaxique : Emacs, Vim, jEdit, gedit, Texpad...

The screenshot shows the Eclipse IDE interface with several windows open:

- Project Viewer:** Shows a tree view of a project named "presentationPython" containing various files like "example", "main.tex", "note.tex", etc.
- Editor:** Displays two files side-by-side:
 - `module1.py` (top):

```
def f(x):
    y = 10 * x
    return y

def g(x):
    y = 100 * x
    return y

x = 3
y1 = f(x)
y2 = g(x)
print("%s, %s, %s" % (x, y1, y2))
```
 - `sec_environment.tex` (bottom):

```
\begin{itemize}
\item Tout éditeur de texte avec coloration syntaxique : Emacs, Vim, jEdit, Texpad...
\end{itemize}
```
- Console:** Shows an interactive Python session:

```
Interactive Python console.
Starting...
Python 2.7.2 (default, Oct 11 2012, 20:14:37)
[GCC 4.2.1 Compatible Apple Clang 4.0 (tags/Apple/clang-418.0.60)] on darwin
Type help, copyright, credits or license for more information.
>>>
```
- Bottom Status Bar:** Shows "156.14 (6905/7280)" and "latex,none,UTF-8 Smiley UC 44/1MB 1 error(s) 13:34".

Outline

Introduction

Description du Langage

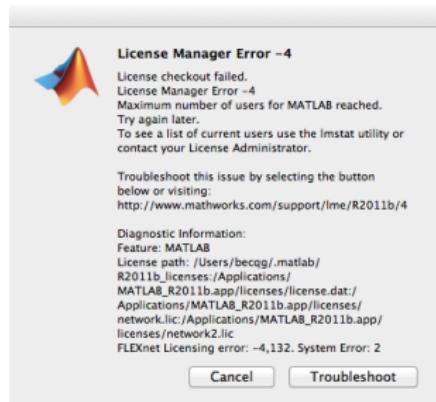
Description des paquets scientifiques

Distributions et Environnements de travail

Conclusion

Python vs Matlab

- ▶ Outils équivalents : matrices vs ndarray, console, script, graphisme, GUI, cell mode vs ipython notebook
- ...
- ▶ Matlab, Matrix Laboratory, a des bibliothèques d'algèbre linéaire plus rapide que Numpy ou Scipy (actuellement).
- ▶ Python est un langage de programmation.
- ▶ Python est plus proche du code C pour prototyper.
- ▶ Chargement des modules à la volée en Python.
- ▶ Python est gratuit.



Outline

classe et variable 'self'

Classe exemples avec self

- ▶ Dans le corps de la classe, 'self' n'est pas défini.

```
class Canard():
...     self.a = 10
...
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
File "<stdin>", line 2, in Canard
NameError: name 'self' is not defined
```

Classe exemples avec self

- ▶ Dans une méthode seul self.nomAttribut est accessible.

```
class Canard():
...     a = 10
...     def __init__(self):
...         self.b = 100
...         print(self.a)
...         print(b)
...
riri = Canard()
10
Traceback (most recent call last):
File "<stdin>", line 1, in <module>
File "<stdin>", line 6, in __init__
NameError: global name 'b' is not defined
```

Classe exemples avec self

- ▶ 'self' est conventionnel.
- ▶ Le premier paramètre d'une méthode est considéré comme l'objet lui même.

```
class Canard():
...     def __init__(obj):
...         obj.a = 10
...         print(obj.a)
...
riri = Canard()
10
```

Classe exemples avec self

- ▶ Possibilité de rajouter des arguments optionnels lors de l'instanciation d'un objet.

```
class Canard():
...     def __init__(self, patte=2):
...         self.a = patte
...         print(self.a)
...
riri = Canard(patte=3)
3
```