Introduction to python and sklearn

(version 2.7, mid-2010)

I. Tinnirello

How to install Python?

- ➔ **From python web site versions >=2.7 (available for all OSs)**
  - ⇨ https://www.python.org/downloads/release/python-2710/
  - ⇨ e.g. for windows: Windows x86 MSI installer
    - →Install on C:\Python
- ➔ **add scientific libraries by means of ‘pip install <module>’**
  - ⇨ NumPy >=1.8
  - ⇨ SciPy >= 0.13
  - ⇨ Sklearn

Should I be a programmer?

- ➔**Not necessarily!**
  - ⇨Better if you have some basis of programming models and languages
- ➔**It is mostly required to be an 'integrator'**
  - ⇨You will need to connect modules, import data and apply minor modifications on available scripts
- ➔**Python is a very high-level language, easy to use**

Python Basics

Interactive “Shell”

- Great for learning the language
- Great for experimenting with the library
- Great for testing your own modules
- Type statements or expressions at prompt:

```
>>> print "Hello, world"
Hello, world
>>> x = 12**2
>>> x/2
72
>>> # this is a comment
```

Numbers

- ➔ **The usual suspects**
  - ➔12, 3.14, 0xFF, 0377, (-1+2)*3/4**5, abs(x), 0<x<=5
- ➔ **C-style shifting & masking**
  - ➔1<<16, x&0xff, x|1, ~x, x^y
- ➔ **Integer division truncates :-(**
  - ➔1/2 -> 0 # 1./2. -> 0.5, float(1)/2 -> 0.5
  - ➔Will be fixed in the future
- ➔ **Long (arbitrary precision), complex**
  - ➔2L**100 -> 1267650600228229401496703205376L
    - » In Python 2.2 and beyond, 2**100 does the same thing
  - ➔1j**2 -> (-1+0j)

Strings

→"hello"+"world"	"helloworld"	# concatenation
→"hello"*3	"hellohellohello"	# repetition
→"hello"[0]	"h"	# indexing
→"hello"[-1]	"o"	# (from end)
→"hello"[1:4]	"ell"	# slicing
→len("hello")	5	# size
→"hello" < "jello"	1	# comparison
→"e" in "hello"	1	# search
→'''single quotes'		

Lists

- ➔**Flexible arrays, even with heterogeneous data**
  - →a = [99, "bottles of beer", ["on", "the", "wall"]]
- ➔**Same operators as for strings**
  - →a+b, a*3, a[0], a[-1], a[1:], len(a)
- ➔**Item and slice assignment**
  - →a[0] = 98
  - →a[1:2] = ["bottles", "of", "beer"]
    - -> [98, "bottles", "of", "beer", ["on", "the", "wall"]]
  - →del a[-1]   # -> [98, "bottles", "of", "beer"]

More List Operations

```
>>> a = range(5)           # [0,1,2,3,4]
>>> a.append(5)            # [0,1,2,3,4,5]
>>> a.pop()                # [0,1,2,3,4]
5
>>> a.insert(0, 42)        # [42,0,1,2,3,4]
>>> a.pop(0)               # [0,1,2,3,4]
5.5
>>> a.reverse()            # [4,3,2,1,0]
>>> a.sort()               # [0,1,2,3,4]
```

Dictionaries

- **Hash tables, "associative arrays"**
  - d = {"duck": "eend", "water": "water"}
- **Lookup:**
  - d["duck"] -> "eend"
  - d["back"] # raises KeyError exception
- **Delete, insert, overwrite:**
  - del d["water"] # {"duck": "eend"}
  - d["back"] = "rug" # {"duck": "eend", "back": "rug"}
  - d["duck"] = "duik" # {"duck": "duik", "back": "rug"}

More Dictionary Ops

- **Keys, values, items:**
  - d.keys() -> ["duck", "back"]
  - d.values() -> ["duik", "rug"]
  - d.items() -> [("duck","duik"), ("back","rug")]
- **Presence check:**
  - d.has_key("duck") -> 1; d.has_key("spam") -> 0
- **Values of any type; keys almost any**
  - {"name":"Guido", "age":43, ("hello","world"):1, 42:"yes", "flag": ["red","white","blue"]}

Dictionary Details

- ➔**Keys must be immutable:**
  - ⇨numbers, strings, tuples of immutables
    - →these cannot be changed after creation
  - ⇨reason is *hashing* (fast lookup technique)
  - ⇨**not** lists or other dictionaries
    - →these types of objects can be changed "in place"
  - ⇨no restrictions on values
- ➔**Keys will be listed in arbitrary order**
  - ⇨again, because of hashing

Tuples

- **key = (lastname, firstname)**
- **point = x, y, z # parentheses optional**
- **lastname = key[0]**
- **singleton = (1,) # trailing comma!!!**
- **empty = () # parentheses!**
- **tuples vs. lists; tuples immutable**

Variables

- → **No need to declare**
- → **Need to assign (initialize)**
  - →use of uninitialized variable raises exception
- → **Not typed**

```
if friendly: greeting = "hello world"
else: greeting = 12**2
print greeting
```

- → ***Everything* is a "variable":**
  - →Even functions, classes, modules

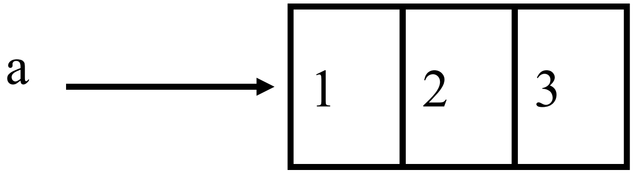
Reference Semantics

- **Assignment manipulates references**
  - x = y **does not make a copy** of y
  - x = y makes x **reference** the object y references
- **Very useful; but beware!**
- **Example:**

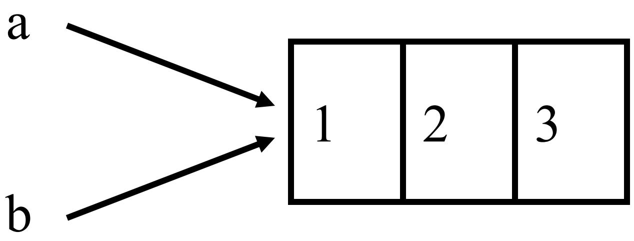
```
>>> a = [1, 2, 3]
>>> b = a
>>> a.append(4)
>>> print b
[1, 2, 3, 4]
```

Changing a Shared List

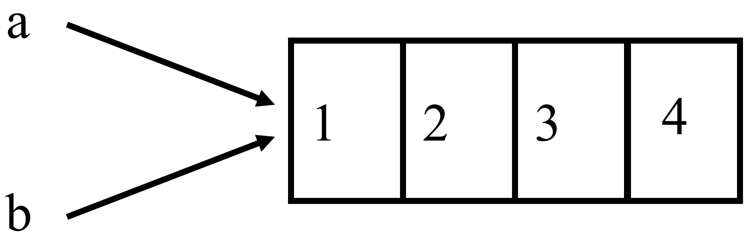
```
a = [1, 2, 3]
```



```
b = a
```



```
a.append(4)
```

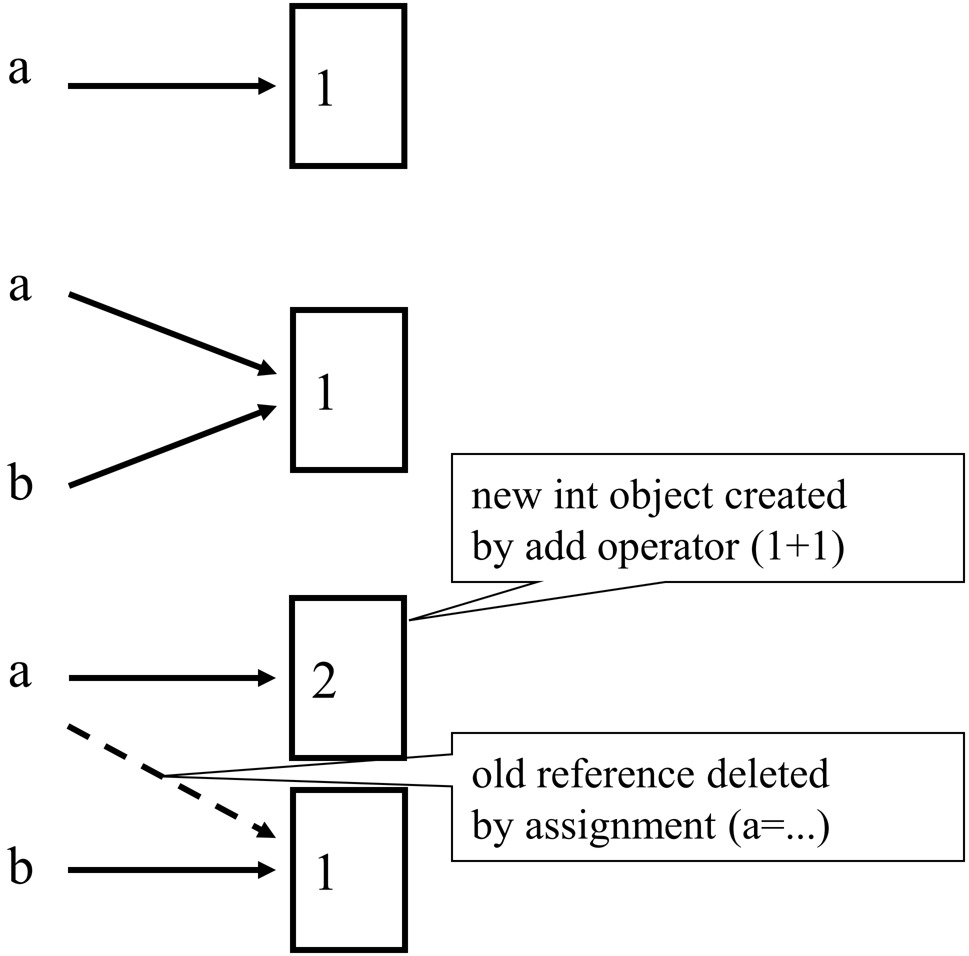


Changing an Integer

```
a = 1

b = a

a = a+1
```



new int object created by add operator (1+1)

old reference deleted by assignment (a=...)

Control Structures

```
if condition:
    statements
[elif condition:
    statements]
  ...
else:
    statements
```

```
while condition:
    statements

for var in sequence:
    statements

break
continue
```

Grouping Indentation

In Python:

```
for i in range(20):
    if i%3 == 0:
        print i
        if i%5 == 0:
            print "Bingo!"
    print "---"
```

In C:

```
for (i = 0; i < 20; i++)
{
    if (i%3 == 0) {
        printf("%d\n", i);
        if (i%5 == 0) {

    printf("Bingo!\n"); }
      }
      printf("---\n");
}
```

```
0
Bingo!
---
---
---
3
---
---
---
6
---
---
---
9
---
---
---
12
---
---
---
15
Bingo!
---
---
---
18
---
---
```

Functions, Procedures

```
def name(arg1, arg2, ...):
    """documentation"""        # optional doc string
    statements

return                         # from procedure
return expression              # from function
```

Example Function

```
def gcd(a, b):
    "greatest common divisor"
    while a != 0:
        a, b = b%a, a    # parallel assignment
    return b

>>> gcd.__doc__
'greatest common divisor'
>>> gcd(12, 20)
4
```

Classes

```
class name:
    "documentation"
    statements
```

-or-

```
class name(base1, base2, ...):
    ...
```

Most, *statements* are method definitions:

```
    def name(self, arg1, arg2, ...):
        ...
```

May also be *class variable* assignments

Example Class

```
class Stack:
    "A well-known data structure…"
    def __init__(self):                          # constructor
        self.items = []
    def push(self, x):
        self.items.append(x)                     # the sky is the limit
    def pop(self):
        x = self.items[-1]                       # what happens if it’s
    empty?
        del self.items[-1]
        return x
    def empty(self):
        return len(self.items) == 0      # Boolean result
```

Using Classes

- ➔ **To create an instance, simply call the class object:**

```
x = Stack()# no 'new' operator!
```

- ➔ **To use methods of the instance, call using dot notation:**

```
x.empty()  # -> 1
x.push(1)  # [1]
x.empty()  # -> 0
x.push("hello") # [1, "hello"]
x.pop()   # -> "hello"
```

- ➔ **To inspect instance variables, use dot notation:**

```
x.items      # -> [1]
```

Subclassing

```
class FancyStack(Stack):
    "stack with added ability to inspect inferior stack items"

    def peek(self, n):
        "peek(0) returns top; peek(-1) returns item below that; etc."
        size = len(self.items)
        assert 0 <= n < size                          # test precondition
        return self.items[size-1-n]
```

Subclassing (2)

```
class LimitedStack(FancyStack):
    "fancy stack with limit on stack size"

    def __init__(self, limit):
        self.limit = limit
        FancyStack.__init__(self)           # base class constructor

    def push(self, x):
        assert len(self.items) < self.limit
        FancyStack.push(self, x)            # "super" method call
```

Class / Instance Variables

```
class Connection:
    verbose = 0                             # class variable
    def __init__(self, host):
        self.host = host                    # instance variable
    def debug(self, v):
        self.verbose = v                    # make instance
    variable!
    def connect(self):
        if self.verbose:              # class or instance variable?
            print "connecting to", self.host
```

Instance Variable Rules

- ➔ **On use via instance (self.x), search order:**
  - ⇨ (1) instance, (2) class, (3) base classes
  - ⇨ this also works for method lookup
- ➔ **On assignment via instance (self.x = ...):**
  - ⇨ always makes an instance variable
- ➔ **Class variables "default" for instance variables**
- ➔ **But...!**
  - ⇨ mutable *class* variable: one copy *shared* by all
  - ⇨ mutable *instance* variable: each instance its own

Modules

- **Collection of stuff in *foo*.py file**
  - functions, classes, variables
- **Importing modules:**
  - import re; print re.match("[a-z]+", s)
  - from re import match; print match("[a-z]+", s)
- **Import with rename:**
  - import re as regex
  - from re import match as m

Packages

- ➔Collection of modules in directory
- ➔Must have __init__.py file
- ➔May contain subpackages
- ➔Import syntax:
  - ⇨from P.Q.M import foo; print foo()
  - ⇨from P.Q import M; print M.foo()
  - ⇨import P.Q.M; print P.Q.M.foo()
  - ⇨import P.Q.M as M; print M.foo()   # new

Catching Exceptions

```
def foo(x):
    return 1/x

def bar(x):
    try:
        print foo(x)
    except ZeroDivisionError, message:
        print "Can’t divide by zero:", message

bar(0)
```

Try-finally: Cleanup

```
f = open(file)
try:
    process_file(f)
finally:
    f.close()           # always executed
print "OK"              # executed on success only
```

File Objects

- **f = open(*filename*[, *mode*[, *buffersize*])**
  - mode can be "r", "w", "a" (like C stdio); default "r"
  - append "b" for text translation mode
  - append "+" for read/write open
  - buffersize: 0=unbuffered; 1=line-buffered; buffered
- **methods:**
  - read([*nbytes*]), readline(), readlines()
  - write(*string*), writelines(*list*)
  - seek(*pos*[, *how*]), tell()
  - flush(), close()
  - fileno()

Standard Library

- **Core:**
  - os, sys, string, getopt, StringIO, struct, pickle, ...
- **Regular expressions:**
  - re module; Perl-5 style patterns and matching rules
- **Internet:**
  - socket, rfc822, httplib, htmllib, ftplib, smtplib, ...
- **Miscellaneous:**
  - pdb (debugger), profile+pstats
  - Tkinter (Tcl/Tk interface), audio, *dbm, ...

URLs

- ➔ **http://www.python.org**
  - ⇨ official site
- ➔ **http://starship.python.net**
  - ⇨ Community
- ➔ **http://www.python.org/psa/bookstore/**
  - ⇨ (alias for http://www.amk.ca/bookstore/)
  - ⇨ Python Bookstore

NumPy additional features

- ➔ **fast, multidimensional arrays**
- ➔ **libraries of reliable, tested scientific functions**
  - ⇨ a powerful N-dimensional array object
  - ⇨ advanced array slicing methods (to select array elements)
  - ⇨ convenient array reshaping methods
  - ⇨ and it even contains 3 libraries with numerical routines:
    - → basic linear algebra functions
    - → basic Fourier transforms
    - → sophisticated random number capabilities
- ➔ **plotting tools**
- ➔ ***We will learn by examples!***

Sklearn

- **Many classes, methods and functions for dealing with machine learning problems**
- **Core data structure:**
  - Dataset
    - dictionary-like object that holds all the data and some metadata about the data
    - .data: n_samples, n_features
    - .target: possible outputs

Loading/Saving

- ➔A=[1 2 3; 4 5 6]
- ➔Numpy.save(‘file’, A);
- ➔C=numpy.load(‘file’);

- ➔e.g. a=matplotlib.image.imread(‘ilenia.jpg’;
- ➔b=a[:, :, 0]

Exercise 1

- ➔Write a python script for recording 5 seconds of audio.
- ➔Save the samples as wav file.
- ➔Try different sampling rates.
- ➔Add a noise in the samples and reproduce the file.