Python Introduction

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Sources: www.csc.villanova.edu/~nlp/python1.ppt
www.cs.umbc.edu/pub/www/courses/graduate/631/Fall2002/Python.ppt
...

Python Features

- interpreted language
- clean syntax, object oriented, powerful

extensions

- useful built-in types (lists, dictionaries)

  → for symbolic AI processing
- easy matrix algebra (module `numpy`)

  → for statistical AI processing
- easy to program GUIs
- easy to produce HTML content

Edit and Run a Program

- IDLE integrated development environment (IDE) for Linux and commercial operating systems
- `ipython` interactive shell for Linux, understands python and ''magic'' commands:
  - `%run file.py` loads and runs a file
  - `%hist` prints history of input
- `python file.py` interpretes the file
- `file.py` runs the file, but first make it executable, and write inside like: `#!/usr/bin/python`

A Sample of Code …

```
x = 4 - 3       # comment: integer difference
y = "Hello"

if x == 0 or y == "Hello":
     x = x + 1
     y = y + " World"  # concatenate string

print x
print y
```

Enough to Understand the Code

- assignment uses = and comparison uses ==
- + -- * / % compute numbers as expected
- use + for string concatenation
- use % for string formatting
- logical operators are words (and, or, not),

  but not symbols (&&, ||, !)
- first assignment to a variable will create it
- Python assigns the variable types

Basic Data Types

- integers (default for numbers)

```
z = 5 / 2    # answer is 2, integer division
```

- floats

```
x = 3.456
```

- strings

Can use `""` or ‘’ to specify. `"abc"` `‘abc’` (same)

Unmatched quotes can occur in the string: `"matt’s"`

Use triple double-quotes for multi-line strings or strings

which contain both ’ and " inside: `"""a‘b"c"""`

Whitespace and Indentation

- use a newline to end a line of code

  (use \ when must go to next line prematurely)

- use consistent indentation to mark blocks of code

Comments

- start comments with # – the rest of line is ignored
- can include a "documentation string" as the first line of any new function or class
  - the development environment, debugger, and other tools use it; good style to include one

```
def my_function(x, y):
  """This is the docstring. This function
     does blah blah blah."""
# The code would go here ...
```

A Sample of Code …

```
x = 4 - 3       # comment: integer difference
y = "Hello"

if x == 0 or y == "Hello":
     x = x + 1
     y = y + " World"  # concatenate string

print x
print y
```

Python and Data Types

- Python determines types automatically: "Dynamic Typing"
- But Python is not casual about types, it enforces them thereafter: "Strong Typing"

E.g., you can’t just append an integer to a string.

```
x = "the answer is "     # x is string
y = 23                   # y is integer
print x + y              # Python complains:

TypeError: cannot concatenate 'str' and 'int' objects
```

Naming Rules

- Names are case sensitive and cannot start with a number. They can contain letters, numbers, and underscores, e.g.:

  `bob    Bob    _bob    _2_bob_    bob_2    BoB`

- There are some reserved words:

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

Multiple Assignment

```
x, y, z = 1, 2, 3
y
```

```
2
```

Class

```
class stack:
    def __init__(self):
        self.items = []
    def push(self, x):
        self.items.append(x)
    def pop(self):
        x = self.items[-1]
        del self.items[-1]
        return x
    def empty(self):
        return len(self.items) == 0
```

Use like:

```
t = stack()
print t.empty()
 True
t.push("hello")
print t.empty()
 False
t.pop()
print t.empty()
 True
```

Many String Operations

- built-in formatting on string data type, e.g.

```
"hello".upper()
 str.upper("hello")           # same

 'HELLO'


"abc;;  456  ".split(";")

 ['abc', '', '  456  ']
```

Printing to Screen

- use % string operator to format output text

```
print "%s xyz %d"  %  ("abc", 34)
                # one single (tuple) object given
                # after the formtting operator %
```

```
abc xyz 34
```

```
print "abc",  "xyz", 34     # does same as above
```

```
# print statement replaced by print() function
in Python 3.0
```

File Reading and Writing

```
fobj = open("infile.txt", "r")

line = fobj.readline()

rest = fobj.read()

fobj.close()
```

```
fobj = open("outfile.txt", "w")

fobj.write("values: %d, %.6f\n" % (4, 1.234))

fobj.close()
```

Module Import: NumPy

```
import numpy

A = numpy.zeros((2,3))

array([[ 0.,  0.,  0.],
       [ 0.,  0.,  0.]])
```

```
from numpy import random

B = random.uniform(0.0,1.0,(2,3))

array([[ 0.05718388,  0.77822063,  0.85527822],
       [ 0.85458464,  0.98040686,  0.9404561 ]])
```

Fast and Slow Python

```
import numpy

I = numpy.ones(10000)
W = numpy.ones((400,10000))
S = numpy.zeros(400)

for t in range(10):
  S += numpy.dot(W, I)
```

```
import numpy

I = numpy.ones(10000)
W = numpy.ones((400,10000))
S = numpy.zeros(400)

for t in range(10):
  for i in range (400):
    for j in range (10000):
      S[i] += W[i][j]*I[j]
```

```
ran in 0.8 seconds
```

```
ran in 49 seconds
```

Neural Networks with Numpy

```
import numpy

I = numpy.ones(10000)
W = numpy.ones((400,10000))


for i in range(10):
  S = numpy.dot(W, I)
```

use vectors (rank 1 arrays)

for neural layer activations

use matrices (rank 2 arrays)

for connection weights

scalar product activates a

neural layer from its input

Pitfall: Inconsistent Modules

```
import numpy

import random

n, r = numpy.zeros(15), numpy.zeros(15)

for i in range (15):

    n[i] = numpy.random.randint(0,2)    # 0 <= n[i] < 2

    r[i] = random.randint(0,2)          # 0 <= r[i] < 3 !

print 'n =', n, '\nr =', r
```

```
n = [ 0. 0. 0. 0. 1. 1. 1. 1. 0. 0. 0. 0. 0. 1. 1.]

r = [ 1. 1. 0. 0. 0. 0. 0. 2. 0. 1. 1. 2. 2. 2. 1.]
```

Pitfall: Inconsistent Vector Handling

```
import numpy, math

a = numpy.ones(2)
numpy.exp(a)                    # numpy can handle vectors
array([2.718, 2.718])

math.exp(a)                     # math expects scalar
TypeError: only length-1 arrays can be converted to Python scalars

map(math.exp, a)      # map: apply function to iterable
[2.718, 2.718]
```

Assignments are by Reference

- `b = a` does not make a copy; it's the same object

e.g.:

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

b = a

a.append(7)

print b
```

[1,2,3,7]

but:

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

c = a[:]

a.append(7)

print c
```

[1,2,3]

```
import numpy

a = [1,2,3]

d = \

numpy.array(a)

a.append(7)

print d
```

[1,2,3]

Pitfall: NumPy Arrays ≠ Lists

```
A=numpy.array([[1,2],
[3,4]])

A[0,1]
   2


A[0,:]     # 0th row
   array([1,2])
A[:,0]     # 0th column
   array([1,3])
```

```
A=[[1,2],[3,4]]

A[0,1]
   TypeError
A[0][1]
   2
A[0][:]
   [1,2]
A[:][0]
   [1,2]    !!
```

Command Line Arguments

```
import argparse

parser = argparse.ArgumentParser()
parser.add_argument('--p1', type=int, default=1)
parser.add_argument('--p2', type=float, default=2.5)
args = vars(parser.parse_args())

print "sum = {}".format(args['p1'] + args['p2'])
```

Use like:

```
python parse.py --p1 4 --p2 3.7


sum = 7.7
```

Embedding C in Python (option 1)

```
import scipy.weave
a, b = 1, 2
c = scipy.weave.inline('return_val = a + b;\
printf("a=%d b=%d\\n", a, b);', ['a','b'])
print "c = %d" % c
```

```
a=1 b=2
c = 3
```

Embedding C in Python (option 2)

array.c

```c
#include <stdlib.h>

void square(int nsize,
           double *v){
  int i;
  for(i=0;i<nsize;i++){
    v[i] = v[i]*v[i];
  }
}
```

call.py

```python
import ctypes

MyLib = ctypes.CDLL('./array.so')
myArray = (5*ctypes.c_double)()
for i in range(5):
    myArray[i] = i
myLib.square(5,myArray)
for i in range(5):
    print(myArray[i])
```

```
gcc -fPIC -c array.c -o array.o
gcc -shared -Wl,-soname, -o array.so -fPIC array.o
```

```
python call.py
0.0
1.0
4.0
9.0
16.0
```

```python
npArray = numpy.frombuffer(myArray)
```

... obtain a proper numpy array

slde content thanks to Mehmet Suzen

Embedding Python in C

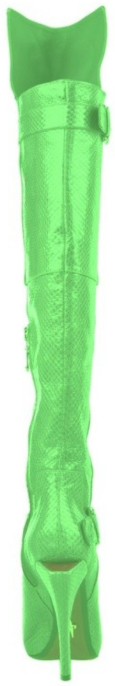
```
void main () {
  Py_Initialize();
  PyRun_SimpleString("k = \"hello\"");
  PyRun_SimpleString("print k");
  Py_Finalize();
}

gcc embedPythonInC.c -lpython2.6
./a.out
hello
```

http://www.rexx.com/~dkuhlman/python_book_01.html#extending-and-embedding-python

Links

- http://python.org
- http://wiki.python.org/moin/BeginnersGuide/Programmers
- http://www.diveintopython.net
- http://www.rexx.com/~dkuhlman/python_book_01.html
- http://rgruet.free.fr
- http://ipython.org
- http://openbook.galileocomputing.de/python

The End



Python Exercises I/II

- Multiply the two matrices: `C = A B =` $\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 0 & -1 \\ 0 & 0 \end{pmatrix}$
- Copy the last two rows of the result `C` into a 2x2 matrix `D`.
- Change a value of `D`. What happens with `C` ?
- What is the difference between: `E=C` and `E=numpy.array(C)` ?
- Which of the following expressions returns the 0th column of `A` ?

  `A[:,0]` or `A[0,:]` or `A[:][0]` or `A[0][:]`
- Append to `A` another column with three times the value -1.

  (to do this, use `numpy.ones` to create a matrix that has a `numpy.shape` of (3,1), and then use `numpy.concatenate`)

Python Exercises II/II

Write a class “stat“. Its constructor creates an empty list.

Its method “sample“ adds its argument (a number) to the list.

Its method “moments“ returns mean and variance of list entries.

Usage of this class is like:

```
 s = stat
 s.sample(3.0)
mean, sigma = s.moments()
```