Python for people who know matlab

Fedor Baart

July 17, 2011

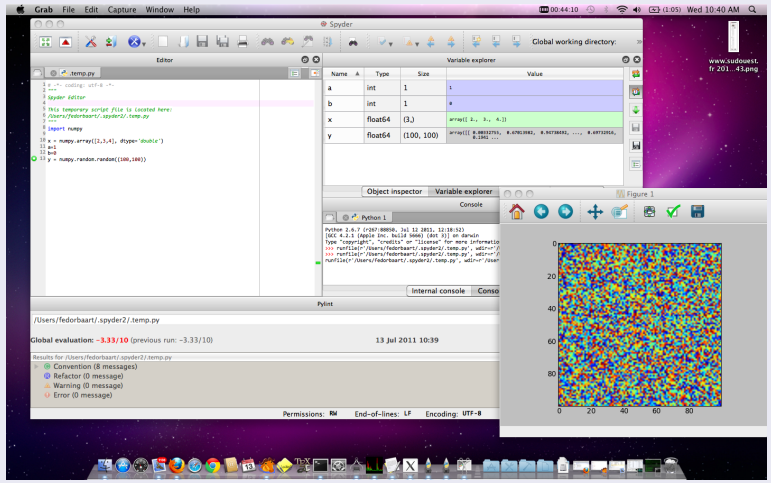
Introduction

Outline

Most popular python IDE (@SO)

15 Spyder

Screenshot

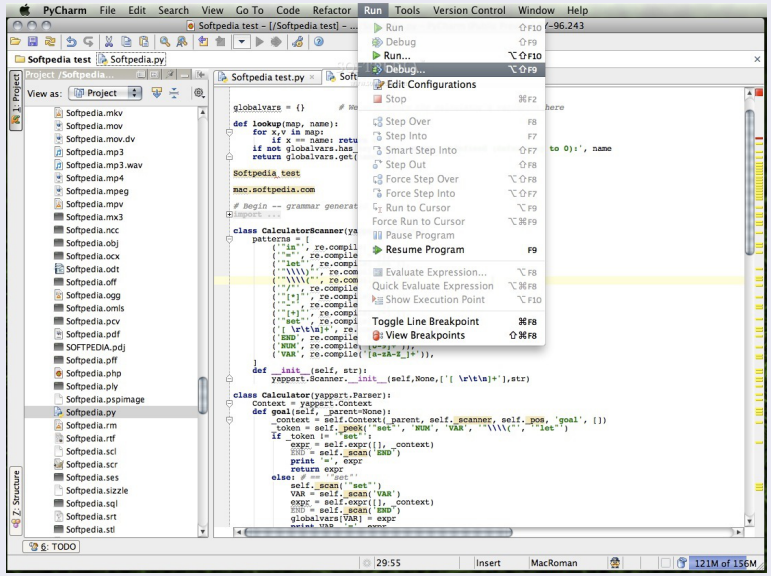


Most popular python IDE (@SO)

4 PyCharm

15 Spyder

Screenshot



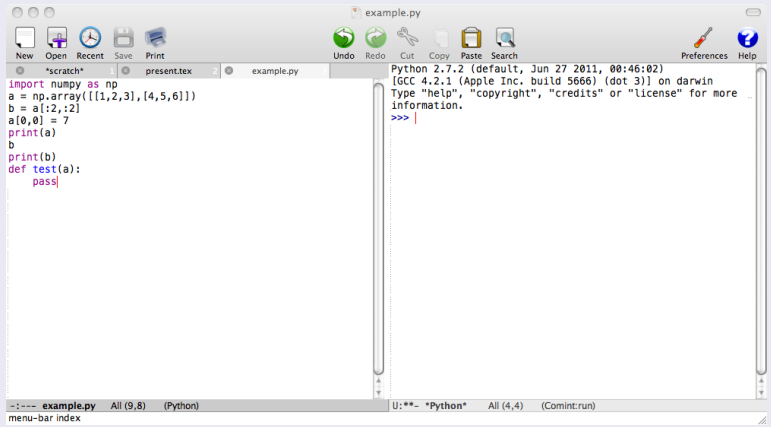
Most popular python IDE (@SO)

3 emacs

4 PyCharm

15 Spyder

Screenshot



Most popular python IDE (@SO)

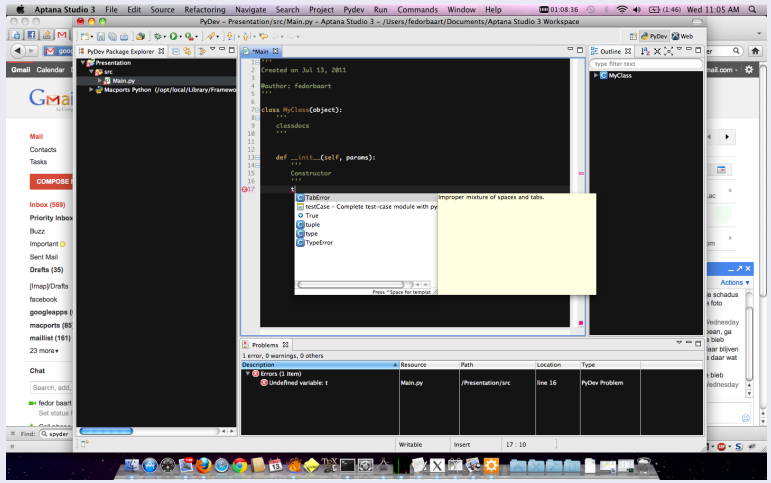
2 PyDev

3 emacs

4 PyCharm

15 Spyder

Screenshot

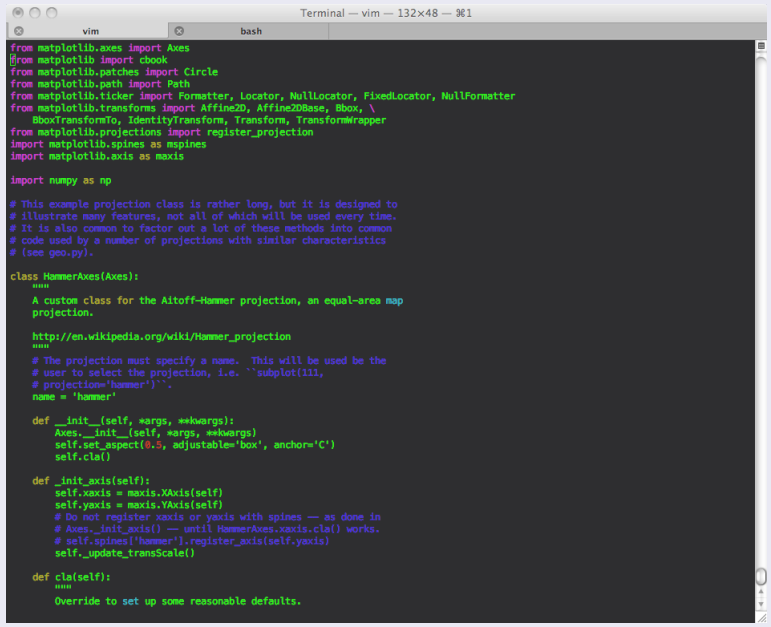


Most popular python IDE (@SO)

1. vim
2. PyDev
3. emacs
4. PyCharm

15. Spyder

Screenshot



Which version?

Python

- Python 2.6, Released October 1st, 2008. Still used by python xy
- Python 2.7, Released July 3rd, 2010. Should be in python xy soon.
- Python 3.x, 3.0 released December 3rd, 2008, start using when all your packages are available.

How to install?

Windows

- Python x,y
- Enthought Python Distribution

Linux

- yum
- apt-get (some extra ppd)
- emerge

How to install?

OSX

- macports (from source)
- homebrew

Extra modules

- pip install module
- pypi.python.org
- python setup.py install

Python

```
help(function) #inline help
pydoc # from command line
pydoc -p 10000 # webserver
```

most python modules have a sphinx doc website: `http://sphinx.pocoo.org/examples.html`

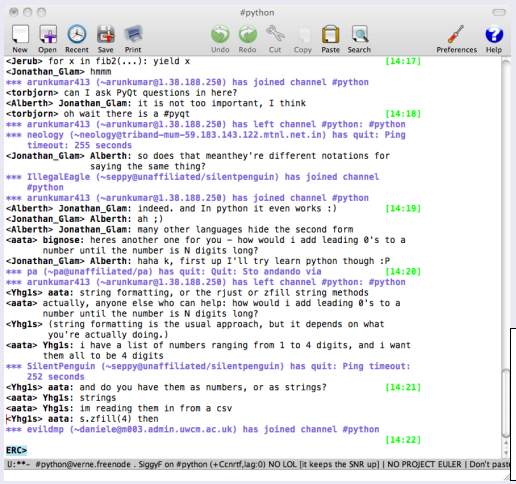
1. docs.python.org
2. docs.scipy.org
3. matplotlib.sourceforge.net

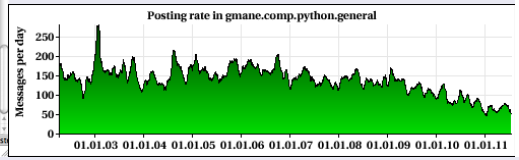
Matlab

```
help function
doc function
```

Communities

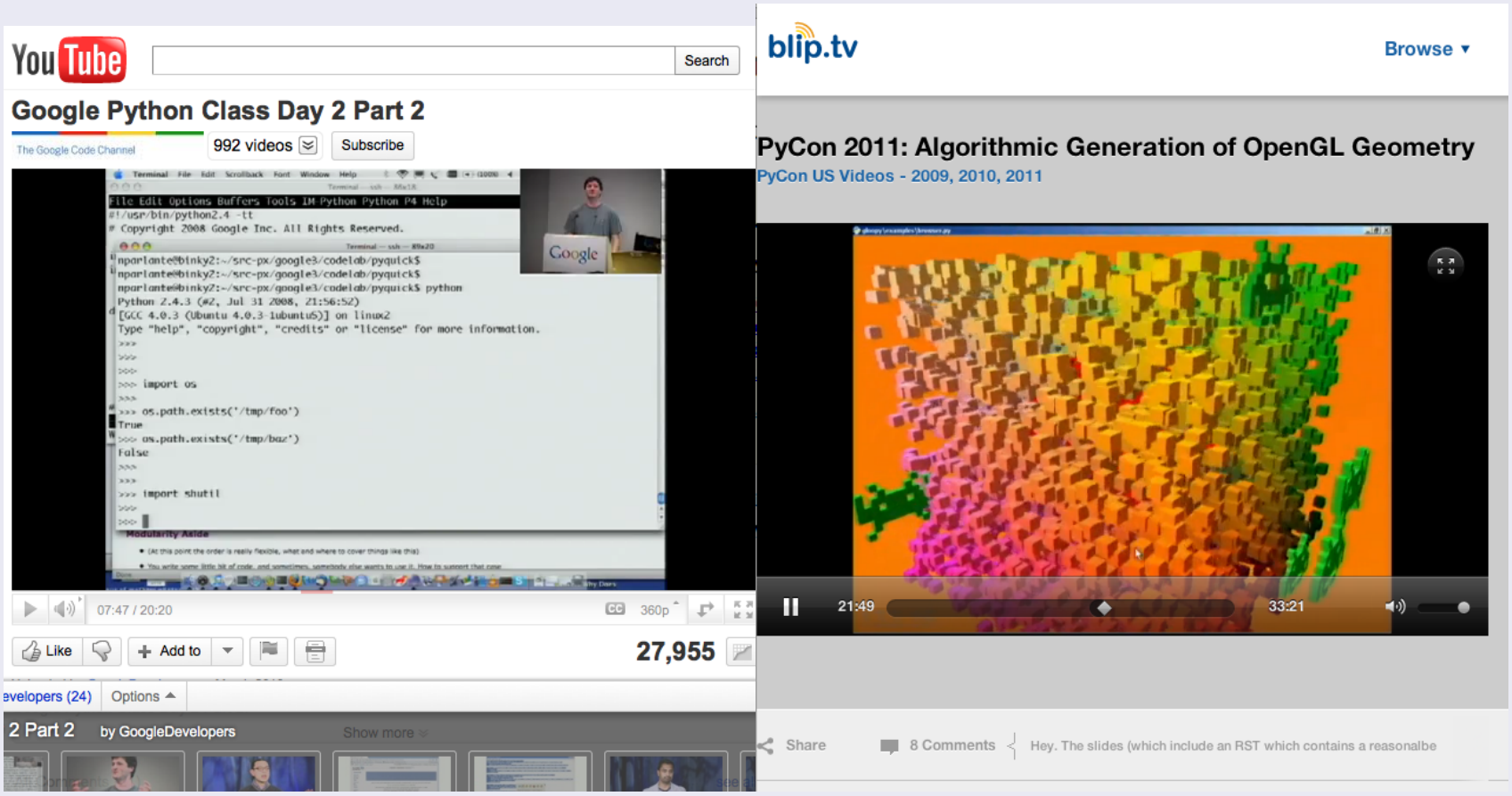
Python





Communities

Python



nice features

```
>>> x = 5
>>> 1 < x < 10
True
>>> 10 < x < 20
False
```

nice features

```
>>> re.compile(
  "[a-z0-9]*" # zero or more small letters or numbers
  "$",        # followed by an end of line
  re.DEBUG    # explain what we're doing
  )
max_repeat 0 65535
  in
    range (97, 122)
    range (48, 57)
at at_end
```

nice features

```
>>> x=(x**2 for x in [0,1,2,3,4] if x>0)
<generator object>
>>> sum(x)
30
```

nice features

```
a = [10, 20, 30, 40, 50]
for index, item in enumerate(a):
  print index, item

0 10
1 20
2 30
3 40
4 50
```

nice features

```
>>> a, b = 1, 2
>>> b,a = a,b
>>> a,b
(2, 1)
```

1

nice features

```
@cache
def somethingdifficult():
  time.sleep(1000)
```

1

nice features

```
def point(x, y):
    # do some magic
point(3, 4)
point(3, y=4)
point(x=3, y=4)
a_tuple = (3, 4)
a_dict = {'y': 3, 'x': 2}
draw_point(*point_foo) # pass in each element
draw_point(**point_bar) # pass named elements
```

nice features

```
def add(x, y):
    """
    add 2 numbers
    >>> add(3, 4)
    7
    """
import doctest
doctest.testmod()
```

nice features

```
"We are at {lat},{lon}".format(lat=52, lon=3)
```

nice features

```
>>> a = {1,2,3,4} # set([]) for python < 2.7?
>>> b = {3,4,5,6}
>>> a | b # Union
{1, 2, 3, 4, 5, 6}
>>> a & b # Intersection
{3, 4}
```

nice features

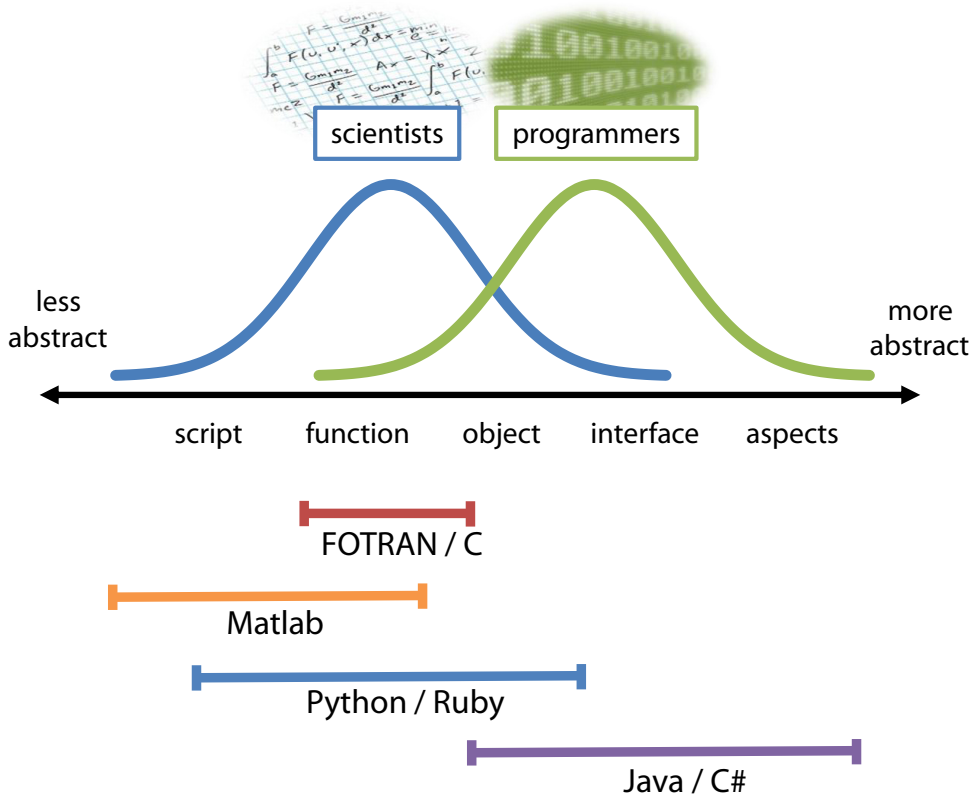
```
>>> str(round(1234.5678, -2))
"1200.0"
```

Outline

What aspects are relevant when choosing a language?

- People (What are the other people making?)
- Paradigma (Object Oriented, Procedural, Functional)
- Help (Documentation, community)
- Data types (dict, list, strings, numbers)
- Type system (int a = 1 vs a = 1)
- Syntax (Keywords, whitespace,braces)
- Libraries (What can you reuse of others?)

People and paradigma



Python

```
>>> x1 = 1 # integer
>>> x2 = 2.0 # float
>>> x3 = "three" # string
>>> x4 = [4,4,4,4] # list
>>> x5 = {5,"five"} # set
>>> x6 = {"six":6} #
    dictionary
>>> x7 = (4,4,4,4) # tuple
```

3

Matlab

```
>> x1 = int16(1) % integer
    (16bit)
>> x2 = 2 % double
>> x3 = "three" % string
>> x7 = {4,4,4,4} % cell
>> %x5 no matlab equivalent
>> x6 = struct('six',6) %
    not quite the same
>> %x7 no matlab equivalent
```

3

Python

```
>>> x1 = 1 # integer
>>> x2 = 2.0 # float
>>> x3 = "three" # string
>>> x4 = [4,4,4,4] # list
>>> x5 = {5,"five"} # set
>>> x6 = {"six":6} #
    dictionary
>>> x7 = (4,4,4,4) # tuple
```

3

Matlab

```
>> x1 = int16(1) % integer
    (16bit)
>> x2 = 2 % double
>> x3 = "three" % string
>> x7 = {4,4,4,4} % cell
>> %x5 no matlab equivalent
>> x6 = struct('six',6) %
    not quite the same
>> %x7 no matlab equivalent
```

3

Python

```
>>> x1 = 1
>>> x1 == 1
True
>>> x1 + 1
2
>>> x1 + 2.0
3.0
>>> x1 + "three"
... unsupported +: 'int'
    and 'str'
>>> 2 * "three"
'threethree'
>>> x2 = 2.0
>>> x2 * "three"
... can't multiply sequence
     by 'float'
```

Matlab

```
>> x1=1;
>> x1==1;
>> x1+1;
>> x1+2.0;
>> x1+'three'
ans =
   117   105   115   102
       102
>> 2 * 'three'
ans =
   232   208   228   202
       202
>> 2.0*'three'
ans =
   232   208   228   202
       202
```

Python

```
>>> 92233720368547758O7 + 1
92233720368547758O8L
>>> 2/3  # 2//3 is explicit
    integer division
0 (0.67 in python3)
```

Matlab

```
>> int64
    (92233720368547758O7)+1
ans =
 92233720368547758O7
>> int64(2)/int64(3)
ans =
   1
```

Python

```
>>> 2.0.is_integer()
True
>>> 2.5.as_integer_ratio()
(5, 2)
>>> 2.0.imag
0.0
```

4

Matlab

```
>> isinteger(2.0)
ans =
     0
>> [a,b] = rat(2.5)
a =          b =
      5            2
>> imag(2.0)
ans =
     0
```

4

9

```
>>> a = "Фёдор"
>>> len(a)
10
>>> print(a)
Фёдор
>>> a = u"Фёдор"
>>> len(a)
5
>>> a.encode("ascii")
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
UnicodeEncodeError: 'ascii' codec can't encode characters in position 0-4: ordinal no
t in range(128)
>>> a.encode("ascii", "xmlcharrefreplace")
'&#1060;&#1105;&#1076;&#1086;&#1088;'
```

Python

```
>>> x1 = array([[1,2,3],
 [4,5,6]])
>>> x1
array([[1, 2, 3],
       [4, 5, 6]])
>>> x1[0,0]
1
>>> x1[1:,1:]
array([[5, 6]])
```

Matlab

```
>> x1 = [1 2 3; 4 5 6]
x1 =
     1     2     3
     4     5     6
>> x1(1,1)
ans =
     1

>> x1(2:end, 2:end)
ans =
     5     6
```

Python

```
>>> x1*x1
array([[ 1,  4,  9],
       [16, 25, 36]])
>>> x1.dot(x1.T)
array([[14, 32],
       [32, 77]])
```

3

Matlab

```
>> x1 .* x1
>> x1 * x1
```

Python

```
>>> print(np.zeros((100,100)))
[[ 0.  0.  0. ...,  0.]
 [ 0.  0.  0. ...,  0.]
...,
 [ 0.  0.  0. ...,  0.]
 [ 0.  0.  0. ...,  0.]]
```

Matlab

```
>> zeros(100)

ans =

   Columns 1 through 13

     0     0     0     0
     0     0     0     0
     0     0     0     0
```

Python

```
>>> a = np.array
    ([[1,2,3],[4,5,6]])
>>> b = a[:2,:2]
>>> a[0,0] = 7
>>> print(a)
[[7 2 3]
 [4 5 6]]
>>> print(b)
[[7 2]
 [4 5]]
```

Matlab

```
a = [1 2 3; 4 5 6];
b = a(1:2,1:2);
a(1,1) = 7
a =
     7     2     3
     4     5     6
b
b =
     1     2
     4     5
```

Python

```
>>> a = 1
>>> a
1
>>> type(a)
<type 'int'>
```

Matlab

```
>> a = 1

a =

     1

>> whos a
  Name      Class

  a         double
```

Python

```
import numpy
numpy.array([])
import numpy as np
np.array([])
from numpy import *
array([])
from numpy import array
array([])
```

Matlab

```
% Matlab>7.6 +parallel/+gpu
    /GPUArray.m
import parallel.gpu.*
GPUArray([])
```

Python

```
>>> dir(1)
['__abs__', ..., 'bit_length', '
     conjugate',
'denominator', ...]
>>> inspect.getfile(inspect)
'/opt/local/.../python2.7/inspect.pyc'
>>> def a(a=1):
...   pass
>>> inspect.getcallargs(a)
{'a': 1}
>>> getframeinfo(currentframe())
Traceback(filename='<stdin>', lineno=1,
     ...)
```

2

7

Matlab

```
% no equivalent to dir (I think)
>> which which
built-in (/Applications/MATLAB_R2011a.
     app/toolbox/matlab/general/which)
>> ?object % only for objects
>> dbstack % only in debugging?
```

4

Python

Startup do nothing and shutdown time.

```
$time python -c"pass"
real 0m1.471s
user 0m0.030s
sys 0m0.036s
```

Matlab

Startup do nothing and shutdown time.

```
$ time matlab -r exit                    1
real 1m8.891s
user 0m11.889s (2s with -
    nodesktop -nojvm)
sys 0m3.184s
```

Other languages

C: 0.000s, Java: 0.3s, Perl 0.001s, Bash 0.001s

Python

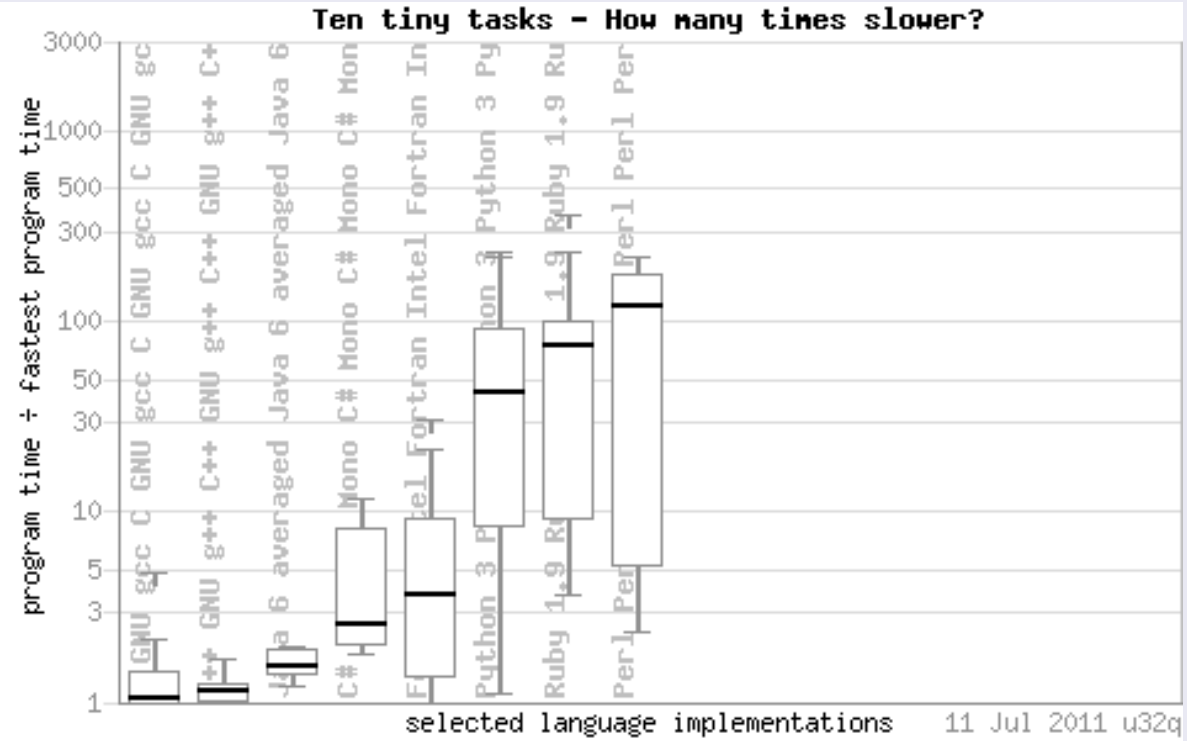
```
>>> setupcode = """
import numpy
x=numpy.zeros((1000,1000))
"""
>>> timeit.timeit('a=x.dot(
    x)',setupcode, number
    =10)
1.5948209762573242
```

Matlab

```
>> x=zeros(1000);
>> tic;for i=1:10;a=x*x;end
    ;toc
Elapsed time is 1.796690
    seconds.
```

Performance shootout

Benchmark (10 different problems)



shootout.alioth.debian.org

Laplace equation

Benchmark using different python techniques (500x500 grid for 100)

- Python: 1500.0s
- Python + NumPy: 29.3s
- Matlab: 29.0s
- Weave 2.3, 4.3, 9.5s
- Fortran 77: 2.9s
- Cython: 2.5s
- Pure C++: 2.16s

`www.scipy.org/PerformancePython`

Outline

- glue (mlabwrap: matlab, ctypes: dll's, fwrap: fortran90)
- plotting (2d: matplotlib, 3d: mayavi, graphs: networkx)
- gis (gdal: data + operations, pyproj: projections)
- data (pydap+netcdf: scientific, sqlalchemy: relational)

Talking to matlab

```
>>> import numpy
>>> from mlabwrap import mlab
>>> X = numpy.random.random((500,500))
>>> mlab.imshow(X)
array([[ 174.00366211]])
```

Talking to a dll

```
>>> import ctypes
>>> libz = ctypes.CDLL('/opt/local/lib/libz.dylib')
>>> ver = libz.zlibVersion
>>> ver.restype = ctypes.c_char_p
>>> ver()
'1.2.5'
```

Wrapping f90

```
function add(x, y, z)
  implicit none
  ! add two vectors and secretly add 1 to the first
      element of x
  real(kind=8), dimension(:,:), intent(inout) :: x
  real(kind=8), dimension(:,:), intent(inout) :: y
  real(kind=8), dimension(:,:), intent(inout) :: z
  integer :: add
  z = x + y
  add = 1
end function add
```

Wrapping f90

```
fwrapc --name=somefunction --fcompiler=gnu95 test.f90
cd somefunction
python setup.py install
python
```

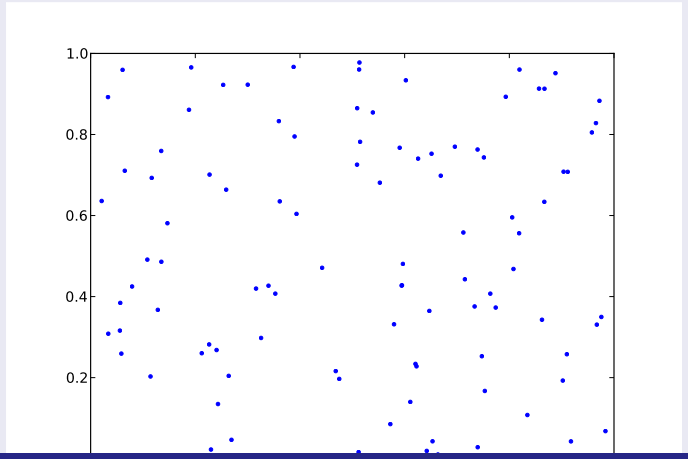
Wrapping f90

```
>>> import numpy
>>> from somefunction import *
>>> x = numpy.ones((5,5), dtype=fwr_real_8, order='F')
>>> y = numpy.ones((5,5), dtype=fwr_real_8, order='F')
>>> z = numpy.empty((5,5), dtype=fwr_real_8, order='F'
    )
>>> (a,b,c,d) = add(x,y,z)
>>> a
1
>>> b is x and c is y
True
>>> d
array([[ 2.,  2.,  2.,  2.,  2.],
       [ 2.,  2.,  2.,  2.,  2.],
       [ 2.,  2.,  2.,  2.,  2.],
       [ 2.,  2.,  2.,  2.,  2.],
       [ 2.,  2.,  2.,  2.,  2.]])
```

Python

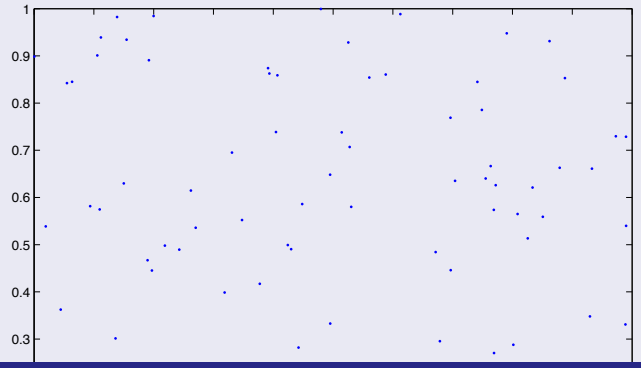
```
>>> plt.plot(random.uniform
    (0,1,100),
                random.uniform
                    (0,1,100),
                '.')
>>> plt.savefig('
    plot1python.pdf')
```

4

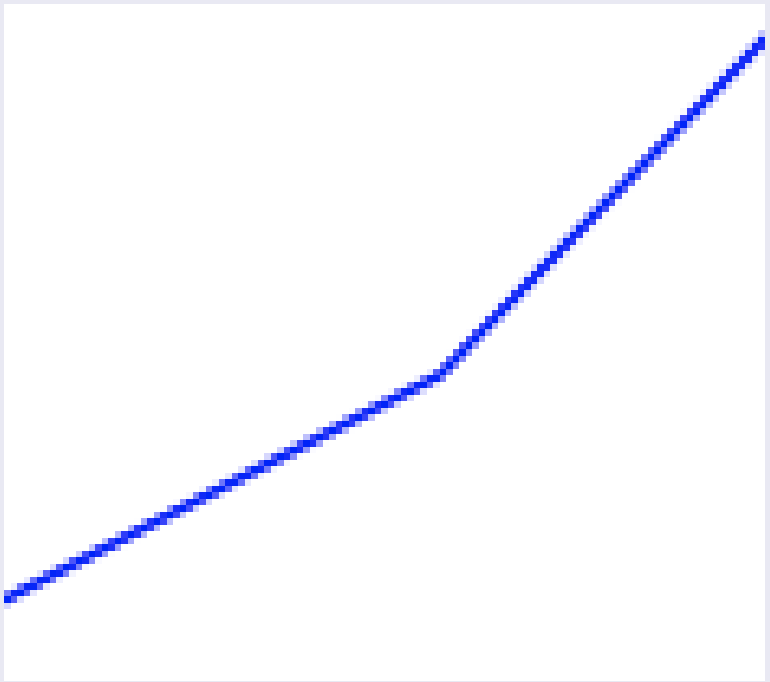


Matlab

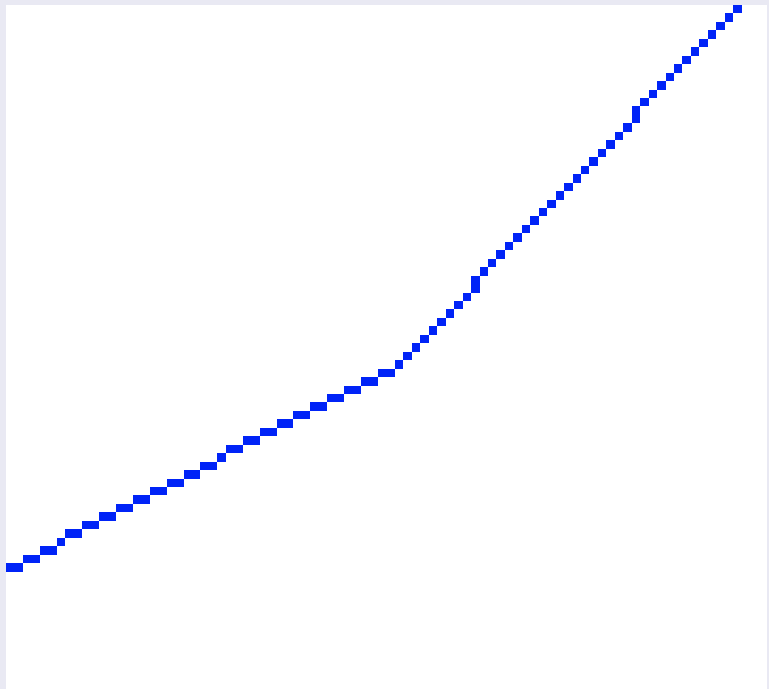
```
>> h = plot(                          1
    random('unif',0,1,1,100)
        ,
    random('unif',0,1,1,100)
        ,
    '.')
h =
   174.0028                           6
>> saveas(h,'plot1matlab.
    pdf')
```



Python



Matlab

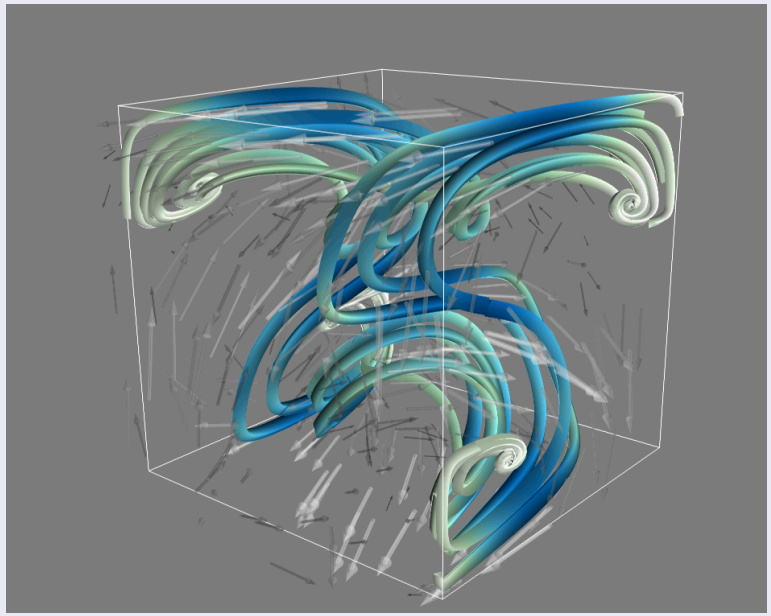


3d plotting

```
import numpy as np
x, y, z = np.mgrid[0:1:20j,
    0:1:20j, 0:1:20j]

u =    np.sin(np.pi*x) * np
   .cos(np.pi*z)
v = -2*np.sin(np.pi*y) * np
   .cos(2*np.pi*z)
w = np.cos(np.pi*x)*np.sin(
   np.pi*z) +
    np.cos(np.pi*y)*np.sin
        (2*np.pi*z)
mlab.quiver3(u,v,w)
mlab.flow(u,v,w)
```

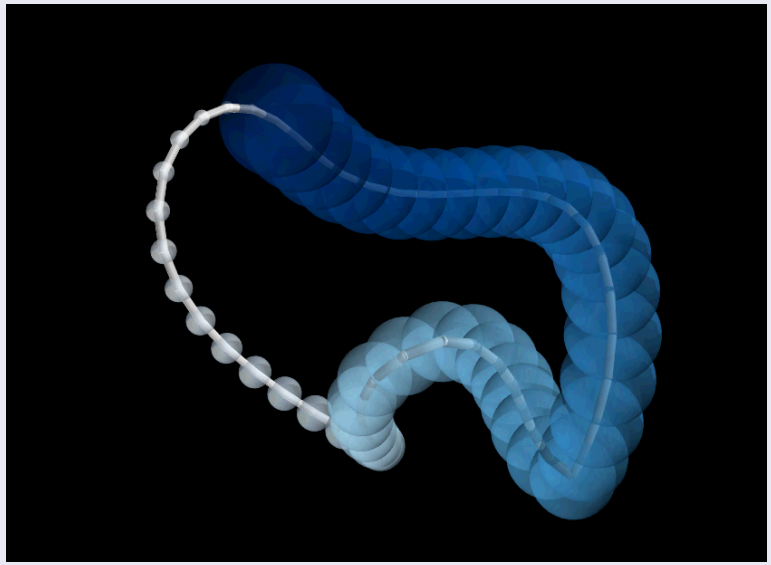
Mayavi plot



networkx

```
import networkx as nx                    1
H = nx.cycle_graph(50)
G = nx.
    convert_node_labels_to_int
    (H)
# layout in 3d
pos = nx.spring_layout(G,
    dim=3)
mlab.points3d( ... )                     6
mlab.pipeline.tube( ... )
```

Networkx plot using mayavi



networkx.lanl.gov

Python with GDAL

```
>>> dataset = ogr.Open('test.kml')
>>> layer = dataset[0]
>>> feature = layer[0]
>>> geometry = feature.geometry()
>>> geometry.GetPoint()
(-122.0822035425683, 37.42228990140251,
     0.0)
>>> geometry.Buffer(3.0).ExportToKML()
'<Polygon>
 <outerBoundaryIs><LinearRing>
   <coordinates>
    -119.082203542568294,37.422289901402507

     ...
```

KML

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml
     /2.2">
  <Placemark>
    <name>Simple placemark</name>
    <description>Attached to the ground.
          Intelligently places itself
       at the height of the underlying
            terrain.</description>
    <Point>
      <coordinates>
           -122.0822035425683,37.422289901402
           </coordinates>
    </Point>
  </Placemark>
</kml>
```

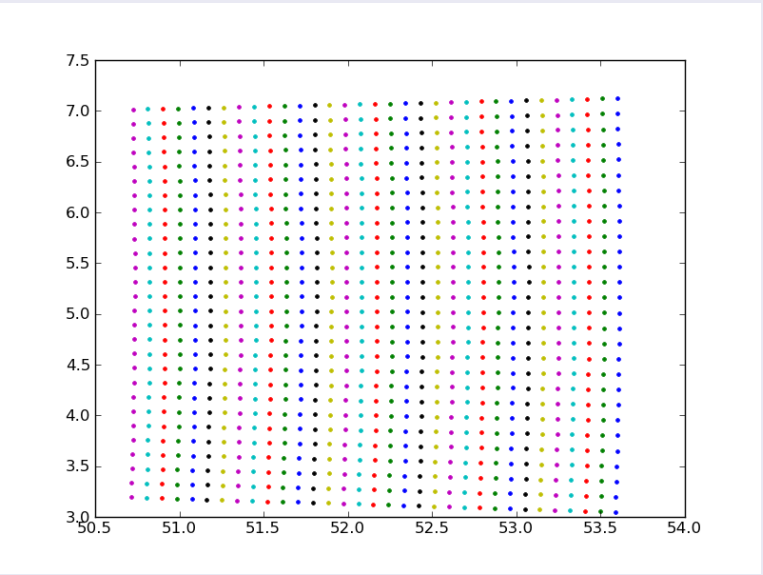
Pyproj

```
from pyproj import Geod
old = Geod(ellps='bessel')
new = Geod(ellps='WGS84')                                                    3
ams_lat = 52.35
ams_lon = 4.917
nyc_lat = 40.+(47./60.)
nyc_lon = -73.-(58./60.)
args = ams_lon,ams_lat,nyc_lon,nyc_lat                                       8
az12,az21, olddist = old.inv(*args) # 5872 km
az12,az21, newdist = new.inv(*args) # 5873 km
```

Python

```
url =
'http://opendap.deltares.nl/thredds/
    dodsC/opendap/tno/ahn100m/mv100.nc
    '
import pydap.client
ds = pydap.client.open_url(url)
ds.keys()
['x', 'y', 'longitude', 'latitude', '
    epsg', 'wgs84', 'depth']
lat = ds['latitude']['latitude']
lon = ds['longitude']['longitude']
depth = ds['depth']['depth']
plt.plot(lat[::100,::100], lon
    [::100,::100], '.')
```

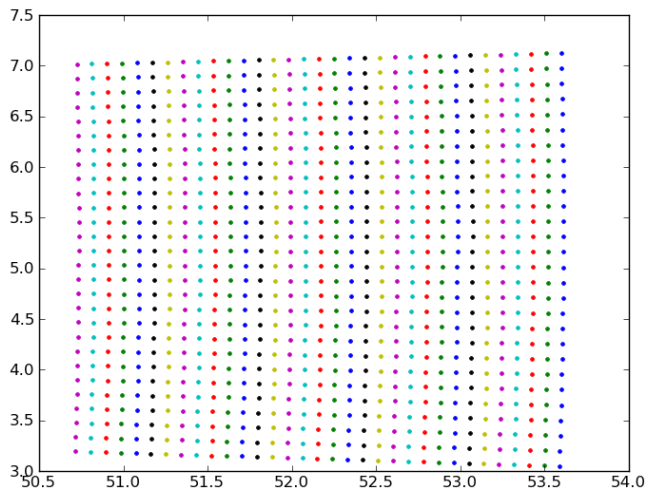
ahn lat/lon



Python

```
lat100 = lat[::100,::100]
lon100 = lon[::100,::100]
idx = reduce(np.logical_and, [
  lat100 < 52.8,
  lat100 > 52.6,
  lon100 > 5.7,
  lon100 < 6.1])
xidx, yidx = np.where(idx)
xslice = slice(xidx.min()*100,xidx.max()
    *100)
yslice = slice(yidx.min()*100,yidx.max()
    *100)
noplat = lat[xslice, yslice]
noplon = lon[xslice, yslice]
nopdep = depth[xslice, yslice]
```

ahn lat/lon

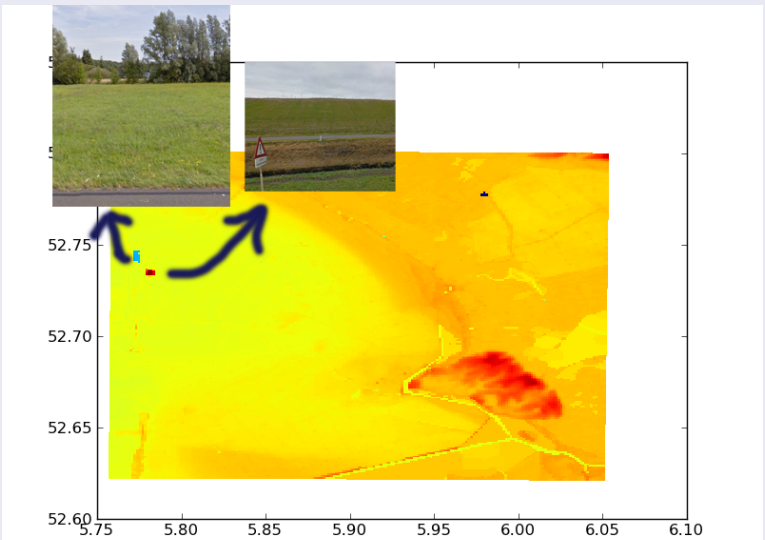


Python

```
plt.pcolormesh(noplon,
    noplat, nopdep)
```

1

ahn lat/lon

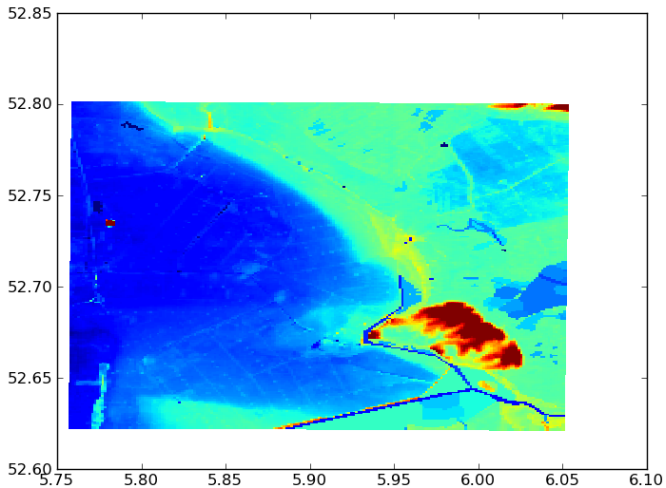


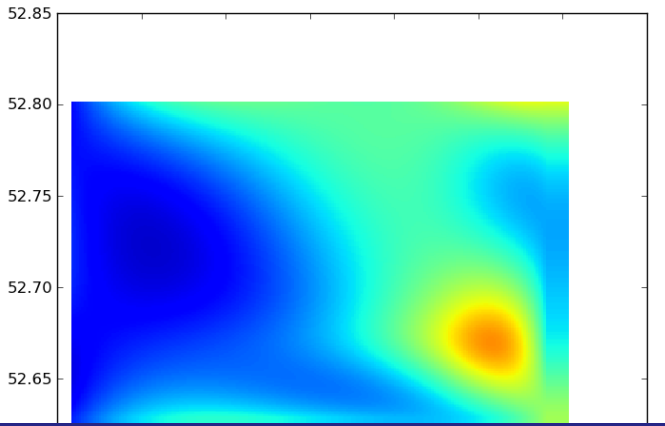
Can we use a rough height map

```
from scipy.interpolate import bisplrep,
     bisplev
roughdep = nopdep[::10,::10]
roughlat = noplat[::10,::10]
roughlon = noplon[::10,::10]
f = bisplrep(roughlon,roughlat,roughdep)
# expects increasing x and y
newdep = bisplev(noplon[:,0], noplat
     [0,::-1], f)[:,::-1].T
plt.pcolormesh(noplon[:,0], noplat[0,:],
      newdep, vmin=-5,vmax=5)
```

4

ahn 100/1000





Outline

```
>>> "%s=%s" % (str(3*0.3),repr(3*0.3))
'0.9=0.89999999999999999'
```

2

```
x = 1.0 / 3
y = 0.333333333333                                    2
print x  #: 0.333333333333
print y  #: 0.333333333333
print x == y  #: False

repr prints too many digits:                          7

print repr(x)  #: 0.3333333333333331
print repr(y)  #: 0.3333333333300003
print x == 0.3333333333333333  #: True
```

```
>>> def a(a=[]):
...   a.append(1)
...   print(a)                                    4
...
>>> a()
[1]
>>> a()
[1, 1]                                             9
```

```
>>> 01                                                          1
1
>>> 07
7
>>> 08
  File "<stdin>", line 1                                       6
    08
     ^
SyntaxError: invalid token
```

```
>>> a=[[1,2,3]]*3
[[1, 2, 3],
 [1, 2, 3],
 [1, 2, 3]]
>>> a[0][0] = 2
[[4, 2, 3],
 [4, 2, 3],
 [4, 2, 3]]
```

1

6

```
>>> i = 1
>>> ++i
1
>>> i
1
```

2

```
      a = 1
a = 2
```