numpy

October 24, 2018

In [2]:
```
from numpy import *
import numpy as np
```

In [8]:
```
# Examples
a = array([1, 2, 4.4])
a**2
np.sin(a)
```

Out[8]:
```
array([ 0.84147098,  0.90929743, -0.95160207])
```

In [9]:
```
# Il ne faut pas utiliser le module math avec des tableaux numpy
import math

math.sin(a)
```

```
---------------------------------------------------------------------------

TypeError                                 Traceback (most recent call last)

<ipython-input-9-702245752729> in <module>()
      2 import math
      3
----> 4 math.sin(a)


TypeError: only length-1 arrays can be converted to Python scalars
```

In [14]:
```
# Comparaison de la vitesse entre une liste et un tableau
a = random.rand(1000000)

%timeit a**2

def carre(x):
    return [elm**2 for elm in x]
b = list(a)

%timeit carre(b)
```

```
1000 loops, best of 3: 791 µs per loop
1 loop, best of 3: 204 ms per loop
```

1 Avantages (et inconvénients) des tableaux

```
In [22]: a = array([1, 2])
         a[0] = 3.14
         a
         # Taille et typde du tableau est fixe

Out[22]: array([3, 2])
```

2 Création d'un tableau

Il existe plusieurs fonctions pour créer un tableau.

- array : partir d'une liste
- zeros, ones, eye
- arange
- linspace, logspace
- loadtxt
- load/save

Le type est déterminé automatiquement. On peut le forcer avec l'argument dtype

```
In [25]: # Array ne fonctionne pas avec un générateur !
         def mon_generateur():
             for _ in range(10):
                 yield 1
             for _ in range(10):
                 yield 2
         array(list(mon_generateur()))

Out[25]: array([1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2])
```

```
In [28]: print(arange(3, 8))
         print(arange(3, 8, 2))
         # arange(debut, fin, pas)
         arange(3, 8, 2.2)

[3 4 5 6 7]
[3 5 7]


Out[28]: array([ 3. ,  5.2,  7.4])
```

```
In [30]: # linspace(debut, fin, N)
         linspace(0, 1, 10)
         dt = 1E-3
         N = 1000
         T_tot = N*dt
         Tt = linspace(0, T_tot, N)
         print(Tt[1] - Tt[0])
```

```
0.001001001001
```

```
In [8]: # Attention pour linspace
        # Si on veut contrôler delta_x, c'est mieux ainsi
        Tt = arange(N)*dt
        len(Tt)
```

```
In [39]: linspace(0, 1, 10, endpoint=False)
```

```
Out[39]: array([ 0. ,  0.1,  0.2,  0.3,  0.4,  0.5,  0.6,  0.7,  0.8,  0.9])
```

```
In [40]: logspace(1, 2, endpoint=False)
```

```
Out[40]: array([ 10.        ,  10.47128548,  10.96478196,  11.48153621,
                 12.02264435,  12.58925412,  13.18256739,  13.80384265,
                 14.45439771,  15.13561248,  15.84893192,  16.59586907,
                 17.37800829,  18.19700859,  19.05460718,  19.95262315,
                 20.89296131,  21.87761624,  22.90867653,  23.98832919,
                 25.11886432,  26.30267992,  27.54228703,  28.84031503,
                 30.1995172 ,  31.6227766 ,  33.11311215,  34.67368505,
                 36.30780548,  38.01893963,  39.81071706,  41.68693835,
                 43.65158322,  45.70881896,  47.86300923,  50.11872336,
                 52.48074602,  54.95408739,  57.54399373,  60.25595861,
                 63.09573445,  66.0693448 ,  69.18309709,  72.44359601,
                 75.8577575 ,  79.43282347,  83.17637711,  87.096359  ,
                 91.20108394,  95.4992586 ])
```

```
In [42]: mon_tableau = loadtxt('/tmp/fichier_data.txt.csv')
         savetxt('/tmp/autre_fichier.txt', mon_tableau)
```

```
In [46]: a = random.rand(100000)

         %timeit savetxt('/tmp/fichier_a.txt', a)
         %timeit loadtxt('/tmp/fichier_a.txt')

         %timeit save('/tmp/fichier_a.npy', a)
         %timeit load('/tmp/fichier_a.npy')
```

```
1 loop, best of 3: 363 ms per loop
1 loop, best of 3: 552 ms per loop
```

```
100 loops, best of 3: 5.89 ms per loop
The slowest run took 4.86 times longer than the fastest. This could mean that an ir
1000 loops, best of 3: 316 µs per loop
```

```
In [50]: zeros(10, dtype=int)
         arange(10, dtype=float)
```

```
Out[50]: array([ 0.,  1.,  2.,  3.,  4.,  5.,  6.,  7.,  8.,  9.])
```

```
In [66]: print(array([2])**63)
         -2**63
```

```
[-9223372036854775808]


/dd_int/anaconda3/lib/python3.5/site-packages/ipykernel/__main__.py:1: RuntimeWarni
  if __name__ == '__main__':
```

```
Out[66]: -9223372036854775808
```

```
In [80]: a = array([1], np.float128)
         b = array([1E-16], np.float128)
         print((a+b) - a)

         a = array([1], np.float64)
         b = array([1E-16], np.float64)
         print((a+b) - a)
```

```
[ 9.996344e-17]
[ 0.]
```

3 Fonctions vectorisées

C'est une fonction qui calcul sur un tableau élément par élément

```
In [83]: x = linspace(-1, 1, 11, endpoint=False)*pi
```

```
In [89]: # Souvent il n'y a rien a faire
         sin(x)

         def ma_fonction(x):
             return sin(x)**2 + cos(x)**2

         print(ma_fonction(x))
```

```
[ 1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.]
```

```
In [90]: # Sinon, on utiliser le décorateur vectorize
         # Mais il existe des solutions pour éviter d'avoir à
         # l'utiliser (c.f. prochaine partie)
         @vectorize
         def mafonction(a):
             if a>0:
                 return a
             else:
                 return -a

         mafonction(x)

Out[90]: array([ 3.14159265,  2.57039399,  1.99919533,  1.42799666,  0.856798  ,
                 0.28559933,  0.28559933,  0.856798  ,  1.42799666,  1.99919533,
                 2.57039399])
```

```
In [91]: # Il faut connaitre l'origine de cette erreur
         if x>0:
             pass


        ---------------------------------------------------------------------------

        ValueError                                Traceback (most recent call last)

        <ipython-input-91-fc516e28ed07> in <module>()
          1 # Il faut connaitre l'origine de cette erreur
    ----> 2 if x>0:
          3     pass


        ValueError: The truth value of an array with more than one element is ambig
```

```
In [94]: (x>0).any()

Out[94]: True
```

4 Indexer un tableau

```
In [98]: x = linspace(-1, 1, 51, endpoint=False)*pi
         # x[start:stop:step], comme range ou arange
         x[4:10:2]

Out[98]: array([-2.64879381, -2.40239438, -2.15599496])

In [99]: slice(4,10,2)

Out[99]: slice(4, 10, 2)
```

In [100]:
```
# C'est un racourcis pour créer un slice
x[slice(4, 10, 2)]
```

Out[100]:
```
array([-2.64879381, -2.40239438, -2.15599496])
```

In [102]:
```
# tout sauf le dernier
x[:-1]
```

Out[102]:
```
array([-3.14159265, -3.01839294, -2.89519323, -2.77199352, -2.64879381,
       -2.52559409, -2.40239438, -2.27919467, -2.15599496, -2.03279525,
       -1.90959553, -1.78639582, -1.66319611, -1.5399964 , -1.41679669,
       -1.29359698, -1.17039726, -1.04719755, -0.92399784, -0.80079813,
       -0.67759842, -0.5543987 , -0.43119899, -0.30799928, -0.18479957,
       -0.06159986,  0.06159986,  0.18479957,  0.30799928,  0.43119899,
        0.5543987 ,  0.67759842,  0.80079813,  0.92399784,  1.04719755,
        1.17039726,  1.29359698,  1.41679669,  1.5399964 ,  1.66319611,
        1.78639582,  1.90959553,  2.03279525,  2.15599496,  2.27919467,
        2.40239438,  2.52559409,  2.64879381,  2.77199352,  2.89519323])
```

In [103]:
```
# Les deux derniers
x[-2:]
```

Out[103]:
```
array([ 2.89519323,  3.01839294])
```

In [109]:
```
# La différence entre deux éléments consécutifs
y = sin(x)
z = y[1:] - y[:-1]
```

In [114]:
```
print(z.sum())
print(y[-1] - y[0])

z.mean()
z.std()
z.min()
z.max()

np.mean(y**2)
(y**2).mean()
```

```
0.122888290665
0.122888290665
```

Out[114]:
```
0.5
```

In [115]:
```
# Indexer avec un tableau d'entier
y[array([1, 4, 6, 2])]
```

Out[115]:
```
array([-0.12288829, -0.47309356, -0.67369564, -0.24391372])
```

```
In [120]: # Par exemple : argsort
          # Les trois éléments les plus petits
          y = random.rand(10)
          print(y)
          k = y.argsort()
          print(y[k[:3]])

[ 0.55222481  0.47171723  0.39277078  0.21590448  0.25450486  0.1817899
  0.7326054   0.6828779   0.46761122  0.55089921]
[ 0.1817899   0.21590448  0.25450486]
```

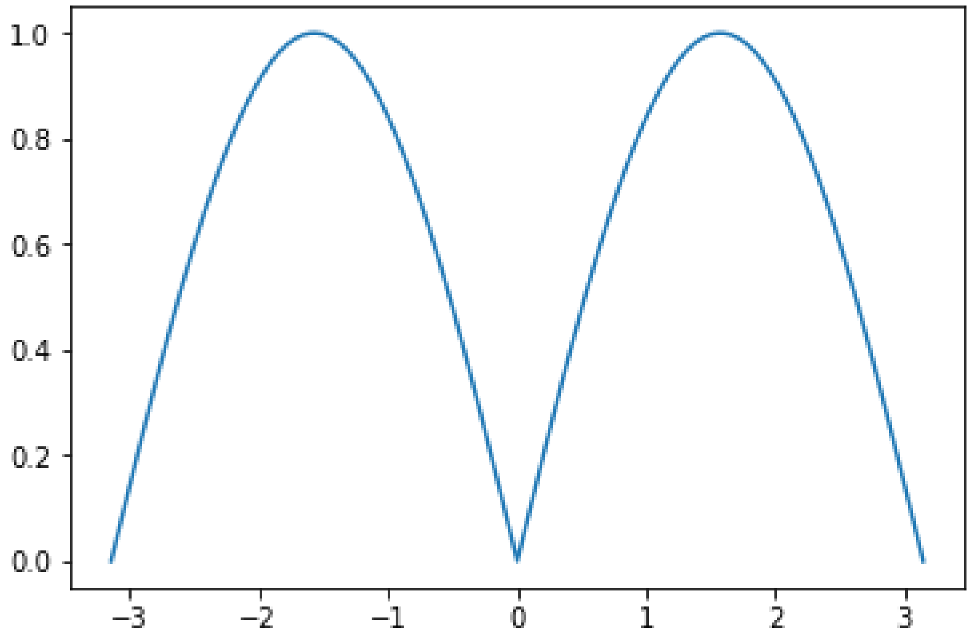
```
In [128]: y = random.rand(10)
          print(y)
          k = y.argsort()

          y[k[:3]] = y[k[-3:]]
          print(y)

[ 0.57958054  0.36060437  0.02491517  0.64643728  0.21258396  0.98147722
  0.90411637  0.33835655  0.81355037  0.80026895]
[ 0.57958054  0.36060437  0.81355037  0.64643728  0.90411637  0.98147722
  0.90411637  0.98147722  0.81355037  0.80026895]
```

```
In [ ]:
```

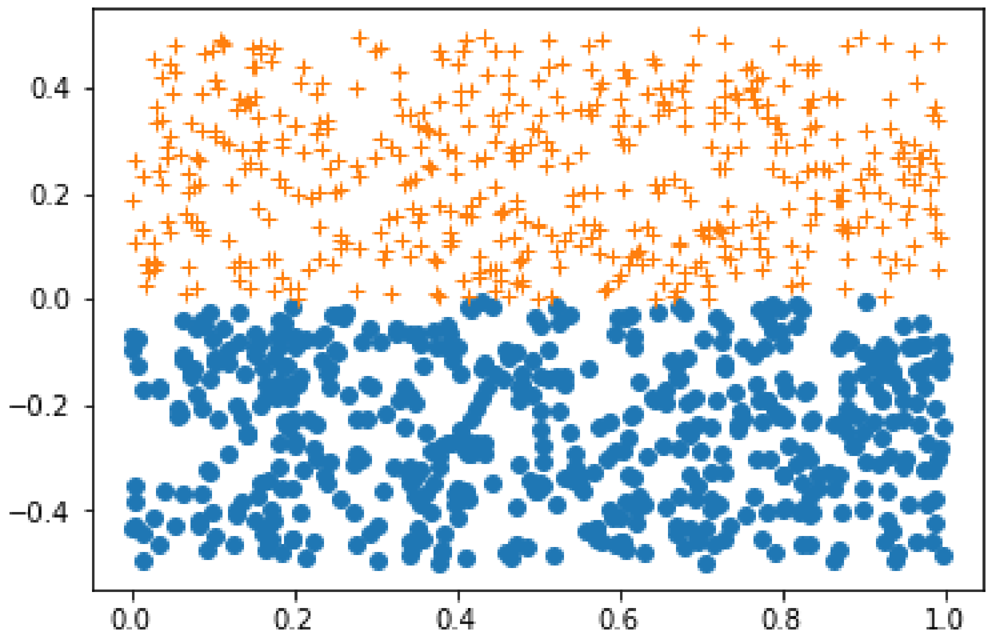
```
In [129]: # Avec un tableau de booléens
          a = array([1, 5, 6])
          b = array([True, False, True])
          a[b]

Out[129]: array([1, 6])
```

```
In [132]: a = random.rand(10)-.5
          a[a<0] = 0
          a

Out[132]: array([ 0.16082526,  0.08950054,  0.        ,  0.19401739,  0.12452296,
                  0.46319504,  0.46988457,  0.15950239,  0.        ,  0.47329232])
```

```
In [135]: %matplotlib inline
          import matplotlib.pyplot as plt

          x = linspace(-pi, pi, 201)
          y = sin(x)
          y[y<0] = -y[y<0]
          plt.plot(x, y)

Out[135]: [<matplotlib.lines.Line2D at 0x7f35c5d1f7f0>]
```




```
In [140]: N = 1000
          y = np.random.rand(N) - .5
          x = np.random.rand(N)
          mask = (y>0)
          plt.plot(x[~mask], y[~mask], 'o')
          plt.plot(x[mask], y[mask], '+')

Out[140]: [<matplotlib.lines.Line2D at 0x7f35c5bdc518>]
```




```
In [144]: a = array([True, False, True, False])
          b = array([True, True, False, False])
          print(a & b)
          print(a | b)
          print(a ^ b)
          print(~a)
```

```
[ True False False False]
[ True  True  True False]
[False  True  True False]
[False  True False  True]
```

5 Tableau dans la mémoire

- strides

```
In [147]: a = arange(10)
          b = a[1:4]
```

```
In [151]: b[0] = 10
          a
```

```
Out[151]: array([ 0, 10,  2,  3,  4,  5,  6,  7,  8,  9])
```

```
In [157]: a = arange(10)-1
          a.data.tobytes()
```

```
Out[157]: b'\xff\xff\xff\xff\xff\xff\xff\xff\x00\x00\x00\x00\x00\x00\x00\x00\x01\x0
```

```
In [160]: b = a[::2]
          b.data.tobytes()
```

```
Out[160]: b'\xff\xff\xff\xff\xff\xff\xff\xff\x01\x00\x00\x00\x00\x00\x00\x00\x03\x0
```

```
In [166]: b.strides
```

```
Out[166]: (16,)
```

```
In [167]: a = zeros((4, 4))
          a.strides
```

```
Out[167]: (32, 8)
```

```
In [168]: a = arange(10)
          a.strides = (4,)
          print(a)
```

```
[          0  4294967296           1  8589934592           2 12884901888
           3 17179869184           4 21474836480]
```

6 Modifier un tableau

```
In [ ]: x = random.rand(10)
```

```
In [ ]: x = random.rand(10)
```

```
In [ ]: x = random.rand(10)
        x[x>.5] = .5
```

```
In [ ]:
```

```
In [13]: # Valeur absolue?
```

7 Tableaux nD

```
In [ ]: a = array([[1,2], [3, 4]])
        # l'index est un tuple
```

```
In [ ]: x = random.rand(5, 5)
        # Récupérer une colonne
```

```
In [ ]: # méthode reshape
        x = random.rand(25)
```

```
In [ ]: x = random.rand(5, 3)
        x.strides
```

```
In [ ]: # Attention, numpy évite de recopier la memoire
        x = arange(10)
        b = x[1::2]
        b[2] = 100
        x
```

```
In [ ]: x = arange(10)
        b = x[x%2==0]
        b[2] = 100
        x
```

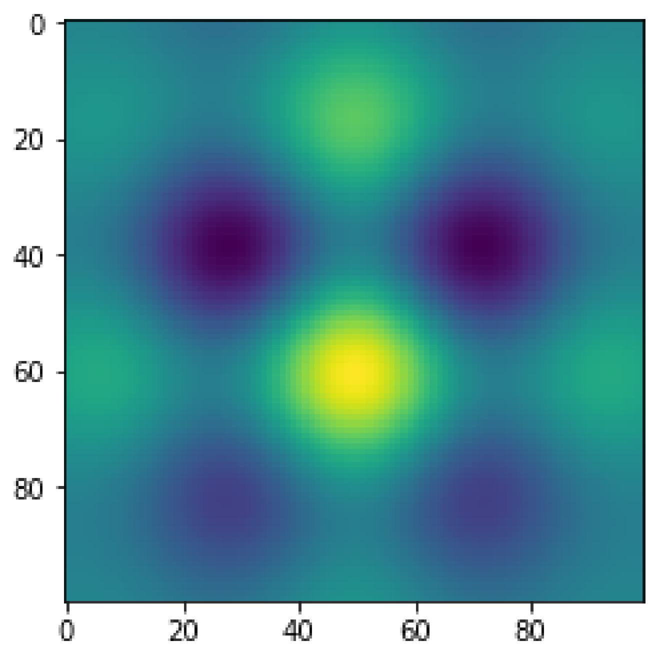
```
In [14]: # meshgrid
```

```
In [15]: %pylab inline
```

```
Populating the interactive namespace from numpy and matplotlib
```

```
In [18]: # Création d'une image 2D avec meshgrid

         x = linspace(-.5, .5, 100)*4*pi
         y = linspace(-.5, .5, 100)*4*pi
         X, Y = meshgrid(x, y)
         R = sqrt(X**2 + Y**2)
         imshow((sin(Y)+cos(X))*exp(-R**2/30))
```

```
Out[18]: <matplotlib.image.AxesImage at 0x7fb5cc8d9940>
```



8 Broadcast

```
In [26]: # Si sur une dimension la taille du tableau vaut 1, alors numpy peut l'éte
         # pour qu'elle est la même valeur que celle de l'autre tableau
         x = random.rand(5, 5)
         a = array([arange(5)])
         print(a.shape)
         x[2:4, :] = a
```

```
(1, 5)
```

```
In [23]: # Il y a une syntaxe simple pour rajouter une dimension de taille 1
         # C'est newaxis
         a = arange(5)
         b = a[newaxis, :]
         x = random.rand(5, 5)
         x[2:4, :] = b
         x
```

```
Out[23]: array([[  7.28573512e-02,   1.42947928e-01,   2.01724084e-01,
                   8.26562378e-01,   1.35450868e-01],
                [  9.40177671e-01,   8.30012529e-01,   4.61468663e-01,
                   5.12394353e-01,   2.81813372e-01],
                [  0.00000000e+00,   1.00000000e+00,   2.00000000e+00,
                   3.00000000e+00,   4.00000000e+00],
                [  0.00000000e+00,   1.00000000e+00,   2.00000000e+00,
                   3.00000000e+00,   4.00000000e+00],
                [  6.94346501e-01,   8.56704397e-02,   6.53554267e-02,
                   2.66422883e-03,   7.49485383e-01]])
```

```
In [27]: # Exemple : calculer une moyenne pondérée
         # Chaque ligne est un élève, chaque colonne un examen
         notes = random.rand(10, 5)*20
         coef = array([1, 4, 2, 5, 8])
```

```
In [28]: # Il est inutile de faire des boucles
```

9 Au delà de numpy : numba

- Calculer π (avec une formule très très lente!!!)

$$\frac{\pi}{4} = \sum_i \frac{(-1)^i}{2i+1} = 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots$$

```
In [29]: def pi_python(N):
             res = 0
             coef = 1
```

```
    for i in range(N):
        res += coef/(2*i+1)
        coef = -coef
    return 4*res

%timeit pi_python(1000000) # 155 ms

def pi_np(N):
    Ti = arange(N)
    return 4*np.sum((1-2*(Ti%2))/(2*Ti+1))

%timeit pi_np(1000000) # 28.3ms

from numba import jit, int64, float64
numba_pi = jit(float64(int64))(pi_python)

@jit( float64(int64) )
def pi_python(N):
    res = 0
    coef = 1
    for i in range(N):
        res += coef/(2*i+1)
        coef = -coef
    return 4*res
%timeit numba_pi(1000000)
```

```
10 loops, best of 3: 160 ms per loop
10 loops, best of 3: 31.6 ms per loop
100 loops, best of 3: 8.87 ms per loop
```