

Librerías científicas en Python:

NumPy

NumPy

- `import numpy`
- Paquete de python que implementa ***colecciones*** de datos de forma eficiente.
- Similar a las listas estandar.
- Internamente, garantiza que los datos están contiguos en la memoria → rápido acceso.
- Arrays de numpy son considerablemente más rápidos que listas para operaciones numéricas.
- Internamente utiliza tipos de datos de C

NumPy

```
In [6]: numeros = [1,2,3,4]
```

```
In [7]: numeros_numpy = numpy.array(numeros)
```

```
In [8]: type(numeros)
```

```
Out[8]: list
```

```
In [9]: type(numeros_numpy)
```

```
Out[9]: numpy.ndarray
```

NumPy

- numpy también ofrece mucha funcionalidad extra para aplicaciones numéricas:

```
In [10]: numeros_numpy.  
numeros_numpy.T  
numeros_numpy.all  
numeros_numpy.any  
numeros_numpy.argmax  
numeros_numpy.argmin  
numeros_numpy.argsort  
numeros_numpy.astype  
numeros_numpy.base  
numeros_numpy.byteswap  
numeros_numpy.choose  
numeros_numpy.clip  
numeros_numpy.compress  
numeros_numpy.conj  
numeros_numpy.conjugate  
numeros_numpy.copy  
numeros_numpy.ctypes  
numeros_numpy.cumprod  
numeros_numpy.cumsum  
numeros_numpy.data  
numeros_numpy.min  
numeros_numpy.nbytes  
numeros_numpy.ndim  
numeros_numpy.newbyteorder  
numeros_numpy.nonzero  
numeros_numpy.prod  
numeros_numpy.ptp  
numeros_numpy.put  
numeros_numpy.ravel  
numeros_numpy.real  
numeros_numpy.repeat  
numeros_numpy.reshape  
numeros_numpy.resize  
numeros_numpy.round  
numeros_numpy.searchsorted  
numeros_numpy.setasflat  
numeros_numpy.setfield  
numeros_numpy.setflags  
numeros_numpy.shape
```

NumPy

- Se puede saber el tipo de los elementos del array con el atributo dtype:

```
In [17]: numeros_numpy.dtype
```

```
Out[17]: dtype('int64')
```

```
In [18]: floats_numpy = numpy.array([1.,2.,3,10,5.5])
```

```
In [19]: floats_numpy.dtype
```

```
Out[19]: dtype('float64')
```

Creando Arrays en NumPy

- Formas abreviadas de crear arreglos:

```
In [32]: ceros = numpy.zeros(100)
```

```
Out[32]: array([0, 0, 0, ..., 0, 0, 0])
```

```
In [51]: lista = [1,2,3,4,5] # Una lista estandar
```

```
In [52]: otro_ceros = numpy.zeros_like(lista) # un array de ceros basado en lista
```

```
In [53]: otro_ceros
```

```
Out[53]: array([0, 0, 0, 0, 0])
```

```
0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,  
0., 0., 0., 0., 0., 0., 0., 0., 0.]
```

Arrays de números aleatorios

```
In [27]: from numpy import random as numpy_random
```

```
In [28]: lista_azar = numpy_random.random(10)
```

```
In [29]: len(lista_azar)
```

```
Out[29]: 10
```

```
In [30]: lista_azar
```

```
Out[30]:  
array([ 0.48643022,  0.67351304,  0.31726036,  0.64209621,  0.82233782,  
        0.20268152,  0.03937668,  0.23962648,  0.474803  ,  0.38983222])
```

```
In [31]: numpy_random.random(10)
```

```
Out[31]:  
array([ 0.93184109,  0.3779432 ,  0.53984084,  0.29510925,  0.75508913,  
        0.59194663,  0.95704321,  0.54417432,  0.51413258,  0.60133594])
```

```
In [32]: numpy_random.random(10)
```

```
Out[32]:  
array([ 0.48318427,  0.19214245,  0.43004535,  0.85029769,  0.03929986,  
        0.77117749,  0.07195387,  0.30978705,  0.6257316 ,  0.81006165])
```

Arrays de números aleatorios

```
In [49]: enteros_random = numpy_random.random_integers(1,100,100)
```

```
In [50]: len(enteros_random)
```

```
Out[50]: 100
```

```
In [51]: enteros_random
```

```
Out[51]:
```

```
array([18, 68, 66, 25, 73, 17, 72, 82, 75, 27, 15, 56, 47, 81, 96, 59, 94,  
       93, 20, 99, 16, 88, 99,  1, 17,  6, 19, 17, 13, 19, 26, 73,  7, 62,  
       56, 59, 21, 55,  4,  6, 83, 73, 87, 48, 32, 78, 87,  7, 36, 78, 11,  
       31, 99, 43, 57, 42, 92, 73, 88, 59, 43, 13, 73, 29, 66, 28, 73, 19,  
        8,  7, 18, 46, 43, 35, 62, 84, 27, 59, 34, 84, 12, 80, 11, 41, 40,  
       10,  5, 97, 63, 66, 74, 73, 24, 50, 90, 50, 95, 41, 45, 54])
```

```
In [52]: █
```


Espacio lineal

- Un arreglo de n números distribuidos uniformemente en un intervalo.

```
In [2]: import numpy
```

```
In [3]: espacio = numpy.linspace(0, 1000, 20) # 20 valores en intervalo 0-1000
```

```
In [4]: espacio
```

```
Out[4]:
```

```
array([  0.,      52.63157895,   105.26315789,   157.89473684,  
       210.52631579,   263.15789474,   315.78947368,   368.42105263,  
       421.05263158,   473.68421053,   526.31578947,   578.94736842,  
       631.57894737,   684.21052632,   736.84210526,   789.47368421,  
       842.10526316,   894.73684211,   947.36842105,  1000.      ])
```

Espacio lineal

- Puede aplicar funciones directamente sobre un espacio lineal \rightarrow vectorizacion (*)
- :-O

```
In [6]: def f(x):
...:     return 2 * x
...:

In [7]: y = f(espacio)

In [8]: y
Out[8]:
array([  0.,    105.26315789,   210.52631579,   315.78947368,
    421.05263158,   526.31578947,   631.57894737,   736.84210526,
    842.10526316,   947.36842105,  1052.63157895,  1157.89473684,
   1263.15789474,  1368.42105263,  1473.68421053,  1578.94736842,
   1684.21052632,  1789.47368421,  1894.73684211,  2000.        ])
```

```
In [9]: █
```

Operaciones aritméticas básicas

```
In [55]: A = numpy.arange(5)

In [56]: B = numpy.arange(5, 10)

In [57]: A
Out[57]: array([0, 1, 2, 3, 4])

In [58]: B
Out[58]: array([5, 6, 7, 8, 9])

In [59]: A + B # Suma elemento por elemento
Out[59]: array([ 5,  7,  9, 11, 13])

In [60]: B - A
Out[60]: array([5, 5, 5, 5, 5])

In [61]: A * B
Out[61]: array([ 0,  6, 14, 24, 36])
```

Operaciones aritméticas básicas

```
In [58]: import math
```

```
In [59]: lista1 = numpy.arange(50)
```

```
In [60]: lista1
```

```
Out[60]:
```

```
array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15, 16,
        17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33,
        34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49])
```

```
In [61]: lista1 * math.pi
```

```
Out[61]:
```

```
array([ 0.          ,  3.14159265,  6.28318531,  9.42477796,
        12.56637061,  15.70796327,  18.84955592,  21.99114858,
        25.13274123,  28.27433388,  31.41592654,  34.55751919,
        37.69911184,  40.8407045 ,  43.98229715,  47.1238898 ,
        50.26548246,  53.40707511,  56.54866776,  59.69026042,
        62.83185307,  65.97344573,  69.11503838,  72.25663103,
        75.39822369,  78.53981634,  81.68140899,  84.82300165,
        87.9645943 ,  91.10618695,  94.24777961,  97.38937226,
        100.53096491, 103.67255757, 106.81415022, 109.95574288,
        113.09733553, 116.23892818, 119.38052084, 122.52211349,
        125.66370614, 128.8052988 , 131.94689145, 135.0884841 ,
        138.23007676, 141.37166941, 144.51326207, 147.65485472,
        150.79644737, 153.93804003])
```

Comparación de Arreglos

```
In [68]: lista1 = numpy_random.random_integers(1,10,20)
```

```
In [69]: lista2 = numpy_random.random_integers(1,10,20)
```

```
In [70]: lista1
```

```
Out[70]:
```

```
array([ 8,  9,  3,  6,  5,  8,  5,  8,  4,  9,  1,  1,  3,  9, 10,  9,  2,  
        1,  1,  5])
```

```
In [71]: lista2
```

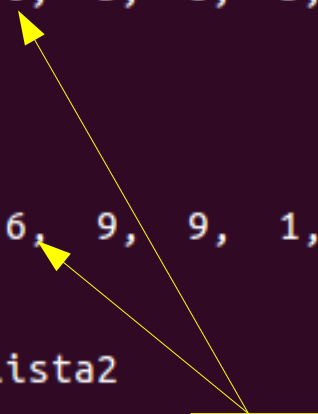
```
Out[71]:
```

```
array([10, 10,  4,  6,  9,  9,  1,  7,  6,  3,  4,  1,  9,  2,  9,  7,  7,  
        8,  7,  6])
```

```
In [72]: lista1 == lista2
```

```
Out[72]:
```

```
array([False, False, False,  True, False, False, False, False, False,  
        False, False,  True, False, False, False, False, False,  
        False, False], dtype=bool)
```



Comparación de Arreglos

- La comparación devuelve otro numpy array.
- Tiene operaciones como `.any()` y `.all()`

```
In [75]: comparacion = lista1 == lista2
```

```
In [76]: comparacion
```

```
Out[76]:  
array([False, False, False,  True, False, False, False, False, False,  
       False, False,  True, False, False, False, False, False, False,  
       False, False], dtype=bool)
```

```
In [77]: comparacion.any()
```

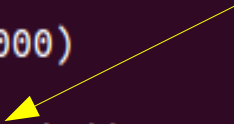
```
Out[77]: True
```

```
In [78]: comparacion.all()
```

```
Out[78]: False
```

Comparación de desempeño

```
In [20]: from operator import add  
In [21]: lista1 = range(100000)  
In [22]: lista2 = range(100000)  
In [23]: %timeit lista3 = map(add, lista1, lista2)  
100 loops, best of 3: 10 ms per loop
```



```
In [30]: import numpy  
In [31]: nlista1 = numpy.arange(100000)  
In [32]: nlista2 = numpy.arange(100000)  
In [33]: %timeit nlista3 = nlista1 + nlista2  
10000 loops, best of 3: 184 us per loop
```

Arreglos multidimensionales

```
In [88]: A = numpy.arange(16)

In [89]: A
Out[89]: array([ 0,  1,  2,  3,  4,  5,  6,  7,  8,  9, 10, 11, 12, 13, 14, 15])

In [90]: matrix_A = A.reshape(4,4)

In [91]: matrix_A
Out[91]:
array([[ 0,  1,  2,  3],
       [ 4,  5,  6,  7],
       [ 8,  9, 10, 11],
       [12, 13, 14, 15]])
```

```
In [103]: matrix_A[:, 3] # Extraer la columna 3
Out[103]: array([ 3,  7, 11, 15])

In [104]: matrix_A[2, :] # Extraer la fila 2
Out[104]: array([ 8,  9, 10, 11])
```


Indexación avanzada

```
In [124]: lista = numpy.arange(5, 10)
```

```
In [125]: lista
```

```
Out[125]: array([5, 6, 7, 8, 9])
```

```
In [126]: lista[[0,2]]
```

```
Out[126]: array([5, 7])
```

```
In [127]: lista[[0,2]] = 0
```

```
In [128]: lista
```

```
Out[128]: array([0, 6, 0, 8, 9])
```

```
In [135]: otro_array = numpy.random.random_integers(0,100,100)
```

```
In [136]: otro_array
```

```
Out[136]:
```

```
array([ 53,  52,  57,  63,  86,  44,  19,  45,  50,   6,  40,  58,  37,
         0,  38,  76,  36,  35,  46,  88,  83,  22,   7,   7,  12,  95,
        11,  53, 100,   4,  21,  18,  88,  25,  98,  54,  53,  61,  53,
        60,  17,  11,  53,  58,  36,  92,  73,  71,  37,  28,  95,  53,
        38,  97,  86,  10,  81,  94,  43,  85,  18,  24,  90,  64,  88,
        68,  76,  81,  42,  29,  90,  79,   9,  40,   0,  44,  48,  54,
        50,  81,  44,  86,  69,  29,   7,  98,  81,   4,  70,   6,  76,
        16,  21,  57,  13,  14,  95,   7,  43,  99])
```

```
In [137]: otro_array[otro_array>50] # Un array con elementos > 50
```

```
Out[137]:
```

```
array([ 53,  52,  57,  63,  86,  58,  76,  88,  83,  95,  53, 100,  88,
        98,  54,  53,  61,  53,  60,  53,  58,  92,  73,  71,  95,  53,
        97,  86,  81,  94,  85,  90,  64,  88,  68,  76,  81,  90,  79,
        54,  81,  86,  69,  98,  81,  70,  76,  57,  95,  99])
```

Diferencias con listas y tupas estándar

- Suma y multiplicación con escalares devuelven resultados diferentes.

```
>>> numpy.arange(5)*2  
array([0, 2, 4, 6, 8])  
>>> range(5)*2  
[0, 1, 2, 3, 4, 0, 1, 2, 3, 4]
```

```
>>> numpy.arange(5) + numpy.arange(5)  
array([0, 2, 4, 6, 8])  
>>> range(5) + range(5)  
[0, 1, 2, 3, 4, 0, 1, 2, 3, 4]
```

Diferencias con listas y tupas estándar

- En numpy, los “slices” son referencias, en listas y tuplas normales, son copias.

```
>>> A = numpy.arange(5)
>>> B = A[0:1]
>>> B[0] = 42
>>> A
array([42,  1,  2,  3,  4])
>>> >>> A = range(5)
>>> B = A[0:1]
>>> B[0] = 42
>>> A
[0, 1, 2, 3, 4]
```

Operaciones sobre numpy arrays

- Mínimo, máximo, promedio, desviación estándar, sumatoria.

```
In [10]: import numpy

In [11]: from numpy.random import random_integers

In [12]: lista = random_integers(0,100,100)

In [13]: lista
Out[13]:
array([33, 34, 16, 78, 40, 71, 97, 95, 62, 96, 77, 44, 18, 58, 76, 17, 20,
        5, 97, 50, 34, 83, 59,  4, 95, 42, 52, 37, 82, 73, 18, 11, 47, 19,
       38, 70,  0, 95, 27, 47, 58, 77, 47, 62, 14, 43, 15, 59, 11, 75, 30,
       99, 61, 91, 43, 37, 12, 14, 33,  6, 13, 18, 36, 72, 94, 75, 71, 49,
       23,  4, 24, 57, 21, 16, 44, 57, 77, 83, 17, 87, 24, 40, 26, 66, 46,
       96, 32, 28, 30, 77, 57, 52, 34,  8, 72, 74, 48, 52, 48, 18])

In [14]: lista.min()
Out[14]: 0

In [15]: lista.max()
Out[15]: 99

In [16]: lista.mean()
Out[16]: 47.700000000000003

In [17]: lista.sum()
Out[17]: 4770
```

Escribir y leer archivos

```
In [66]: lista = random_integers(0,10,1000)
```

```
In [67]: lista.tofile('./numpy_numeros.dat', ',')
```

numpy_numeros.dat ✕

```
1 5,6,3,2,5,5,2,4,0,8,4,2,7,0,10,0,7,2,1,6,0,1,4,1,7,10,2,
```

```
In [74]: lista_leida = numpy.fromfile('./numpy_numeros.dat', sep=',')
```

```
In [75]: len(lista_leida)
```

```
Out[75]: 1000
```

```
In [76]: type(lista_leida)
```

```
Out[76]: numpy.ndarray
```

```
In [77]: lista_leida[0:100]
```

```
Out[77]:
```

```
array([ 5.,  6.,  3.,  2.,  5.,  5.,  2.,  4.,  0.,  8.,  4.,  
        2.,  7.,  0., 10.,  0.,  7.,  2.,  1.,  6.,  0.,  1.,  
        4.,  1.,  7., 10.,  2.,  0.,  7.,  2.,  8.,  9.,  8.,  
        4.,  4.,  1.,  9.,  3., 10.,  4.,  8.,  2.,  6.,  3.,  
        7.,  9.,  0.,  5.,  7.,  1.,  1.,  5.,  9.,  6.,  7.,  
        8.,  4.,  2.,  0.,  1.,  0.,  3.,  2.,  6.,  6.,  2.,  
        2.,  6.,  7.,  0.,  1.,  1.,  7., 10.,  1.,  1., 10.,  
        9.,  3.,  0.,  1.,  4.,  4.,  6.,  9.,  8.,  8.,  9.,  
        8.,  9., 10.,  3.,  8.,  7., 10.,  0.,  3.,  6.,  4.,  
        1.])
```

Matrices en numpy

```
In [121]: A = numpy.matrix([[0, 1],  
                             [2, 3]])
```

```
In [122]: B = numpy.matrix([[4, 5],  
                             [6, 7]])
```

```
In [123]: A.I # Inversa de A
```

```
Out[123]:  
matrix([[ -1.5,  0.5],  
        [ 1. ,  0. ]])
```

```
In [124]: A.T # Transpuesta de A
```

```
Out[124]:  
matrix([[0, 2],  
        [1, 3]])
```

```
In [125]: A.diagonal()
```

```
Out[125]: matrix([[0, 3]])
```

```
In [126]: A+B
```

```
Out[126]:  
matrix([[ 4,  6],  
        [ 8, 10]])
```

```
In [127]: A*B
```

```
Out[127]:  
matrix([[ 6,  7],  
        [26, 31]])
```

Polinomios con Numpy

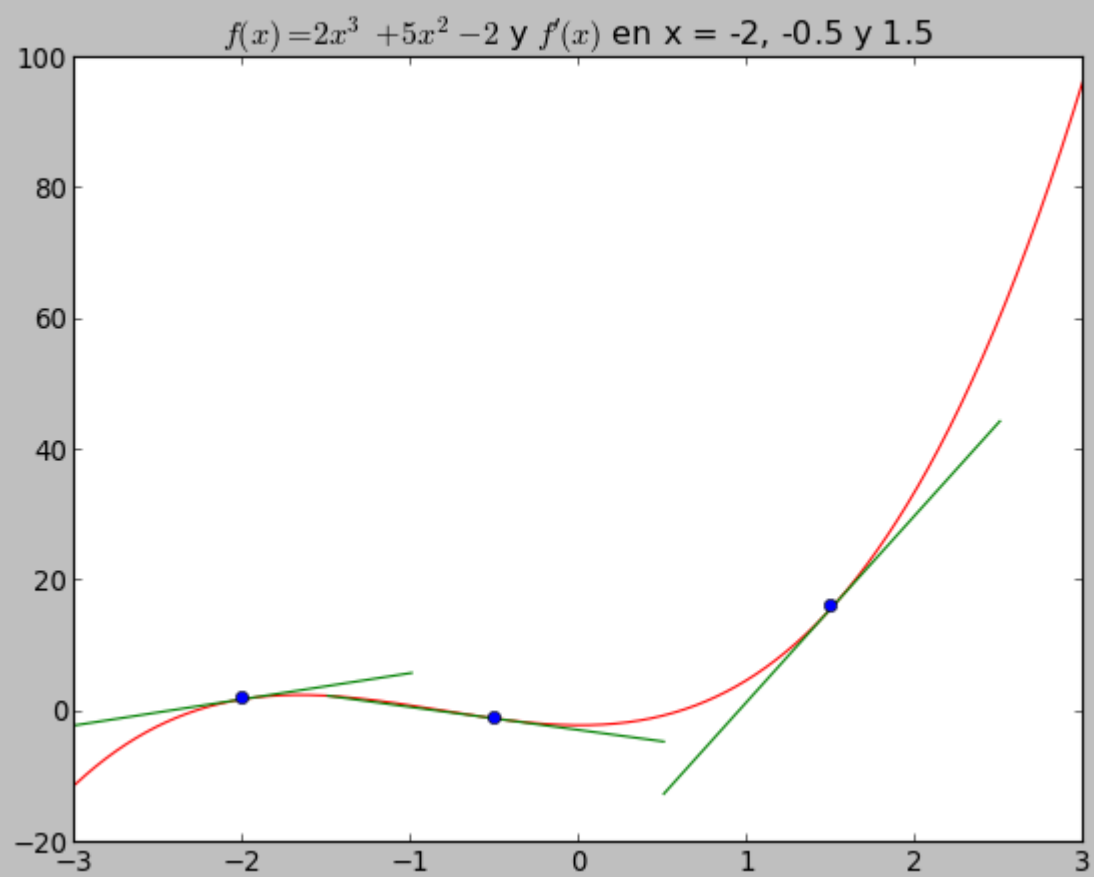
```
In [14]: import numpy as np
In [15]: p = np.poly1d([3, 4, 5])
In [16]: print p
      2
3 x + 4 x + 5
In [17]: print p.deriv() # Derivada del polinomio
      2
6 x + 4
In [18]: print p.integ(k=6)
      3      2
1 x + 2 x + 5 x + 6
```

```
In [34]: p2 = np.poly1d([6, 7, 8]) # Definimos otro polinomio
In [35]: print p + p2 # Suma de polinomios
      2
9 x + 11 x + 13
In [36]: p.order # Orden del polinomio
Out[36]: 2
In [37]: print p(10) # Evaluación del polinomio con la variable en 10
345
```

Ejercicio

- Sea $f(x)$ un polinomio $= 2x^3 + 5x^2 - 2$
- Cree un programa que grafique la función en el intervalo $-3, 3$ (1000 puntos intermedios uniformemente distribuidos).
- Utilice polinomios de Numpy
- Obtenga la derivada $f'(x)$ y grafique la tangente en los puntos $-2, -0.5$ y 1.5

Graficando funciones y su derivada



Ejercicio

- Recuerde que la ecuación de la recta tangente es $y = mx + b$
- Obtenga y evaluando la función en los puntos solicitados (-2, -0.5 y 1.5)
- Obtenga m evaluando la derivada en los puntos solicitados.
- Con y y b , despeje $b = y - mx$
- El x de esa ecuación será un espacio lineal de 100 puntos alrededor de cada punto solicitado.

... y mucho, mucho más!

<http://docs.scipy.org/doc/numpy/genindex.html>

Para usuarios de Matlab:

http://www.scipy.org/NumPy_for_Matlab_Users