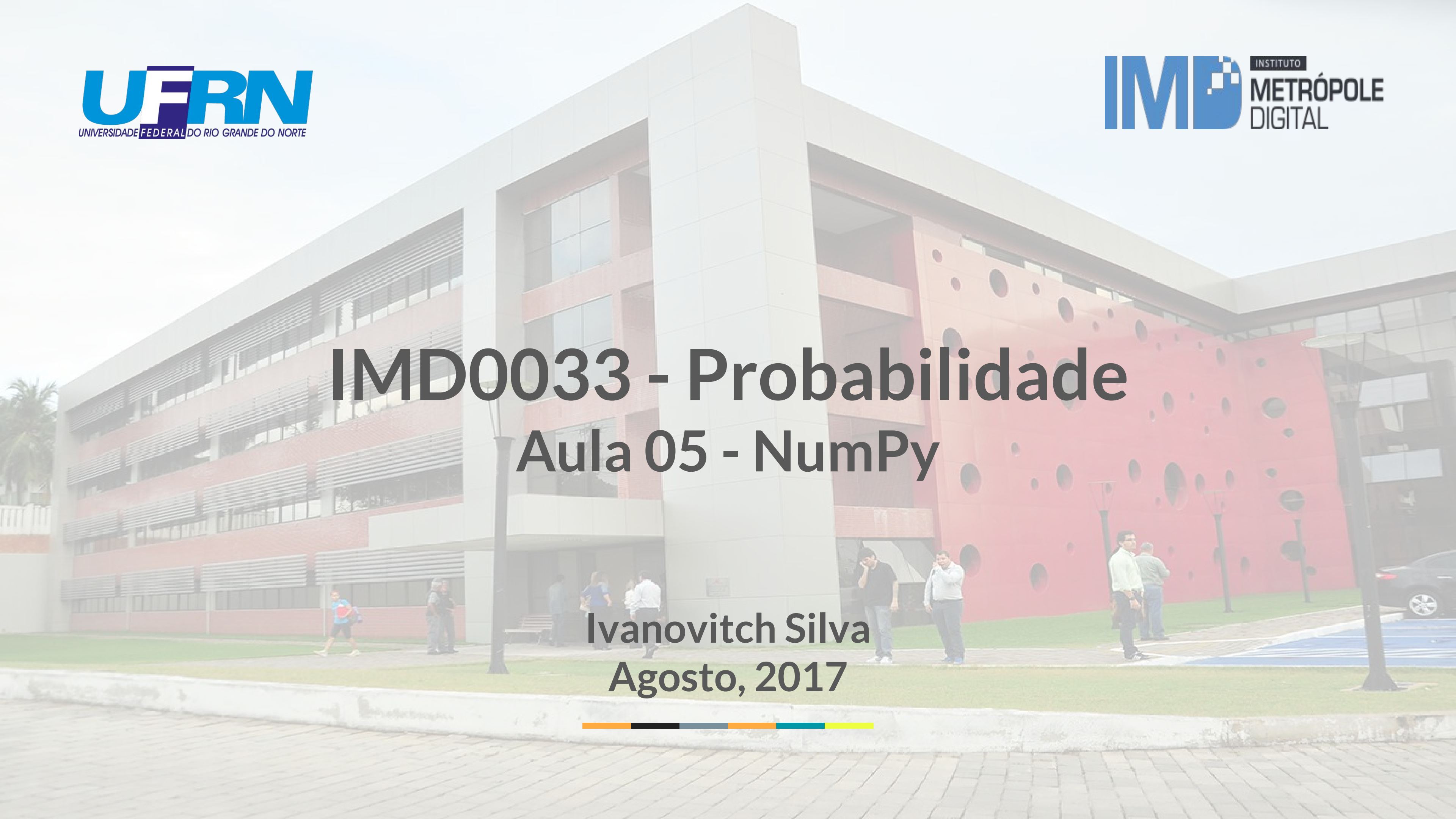


IMD0033 - Probabilidade

Aula 05 - NumPy

Ivanovitch Silva

Agosto, 2017

Agenda

- Motivação
- Introdução sobre NumPy
- Criação de estruturas multidimensionais
- Leitura de arquivos
- Tipos de dados
- Comparando dados
- Funções agregadas
- Vantagens & Desvantagens

Atualizar o repositório

```
git clone https://github.com/ivanovitchm/IMD0033_Probabilidade.git
```

Ou ….

```
git pull
```

Motivação

```
areas = ["hallway", 11.25, "kitchen", 18.0, "living room", 20.0]
```

Trabalhar com Listas em Python tem várias vantagens:

- Armazenar tipos diferentes
- Podem diminuir e crescer dinamicamente

Mas.....

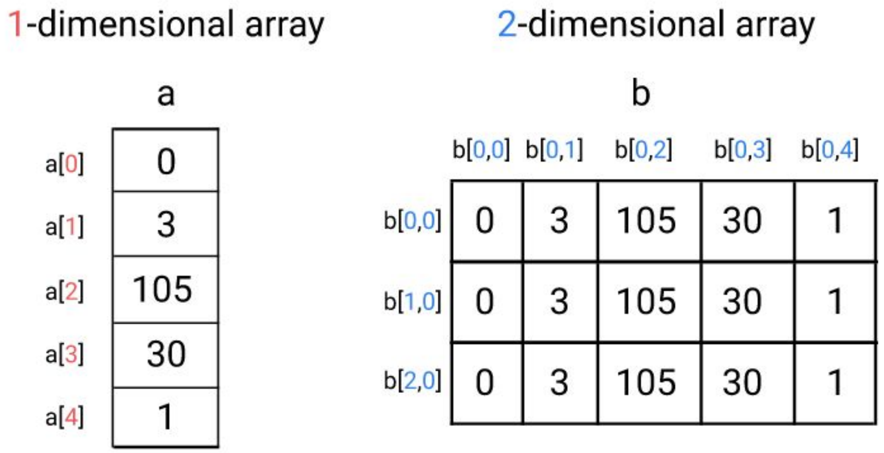
- Para suportar essa flexibilidade, Listas consomem mais memória
- Baixo desempenho para lidar com grande volumes de dados
- Não realizam operações matemáticas entre listas

NumPy

A biblioteca NumPy é o núcleo da computação científica em Python. NumPy fornece alto desempenho para operações para estruturas multidimensionais com a flexibilidade de uso encontrada nas Listas.

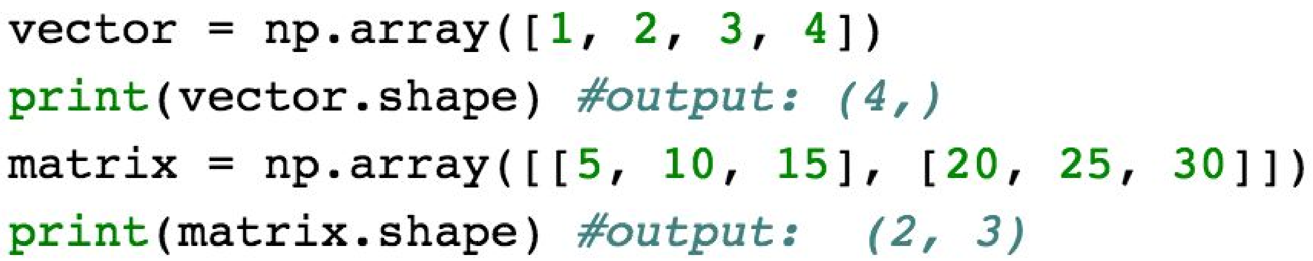
https://goo.gl/0eWPy6

Criando vetores multidimensionais



```
import numpy as np
a = np.array([0,3,105,30,1])
b = np.array([[0,3,105,30,1],[0,3,105,30,1],[0,3,105,30,1]])
```

Imprimindo a dimensão das estruturas

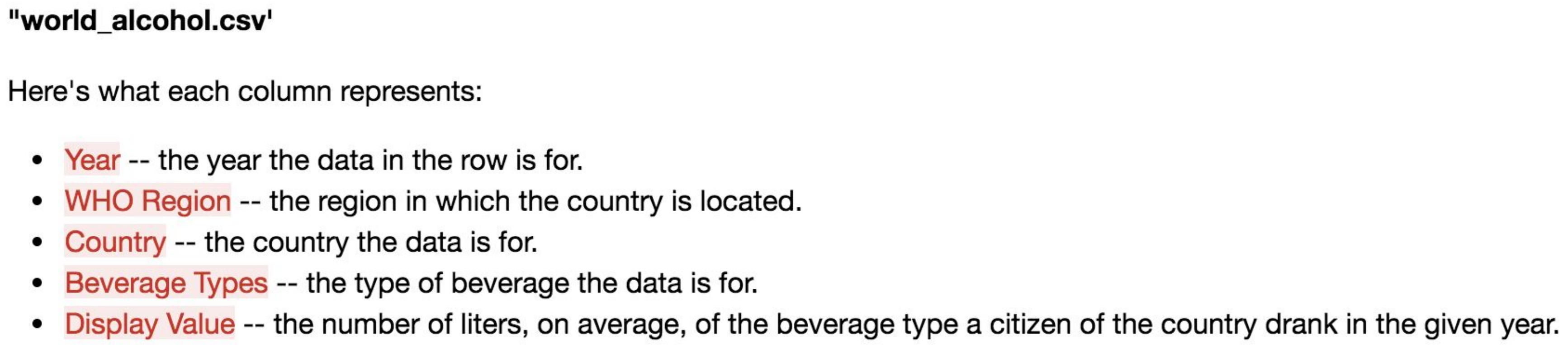


```
vector = np.array([1, 2, 3, 4])
print(vector.shape) #output: (4,)
matrix = np.array([[5, 10, 15], [20, 25, 30]])
print(matrix.shape) #output:  (2, 3)
```

Utilizando NumPy para leitura de arquivos

```python
import numpy
data = numpy.genfromtxt("data.csv", delimiter=",")
```

http://apps.who.int/gho/data/view.main.52160



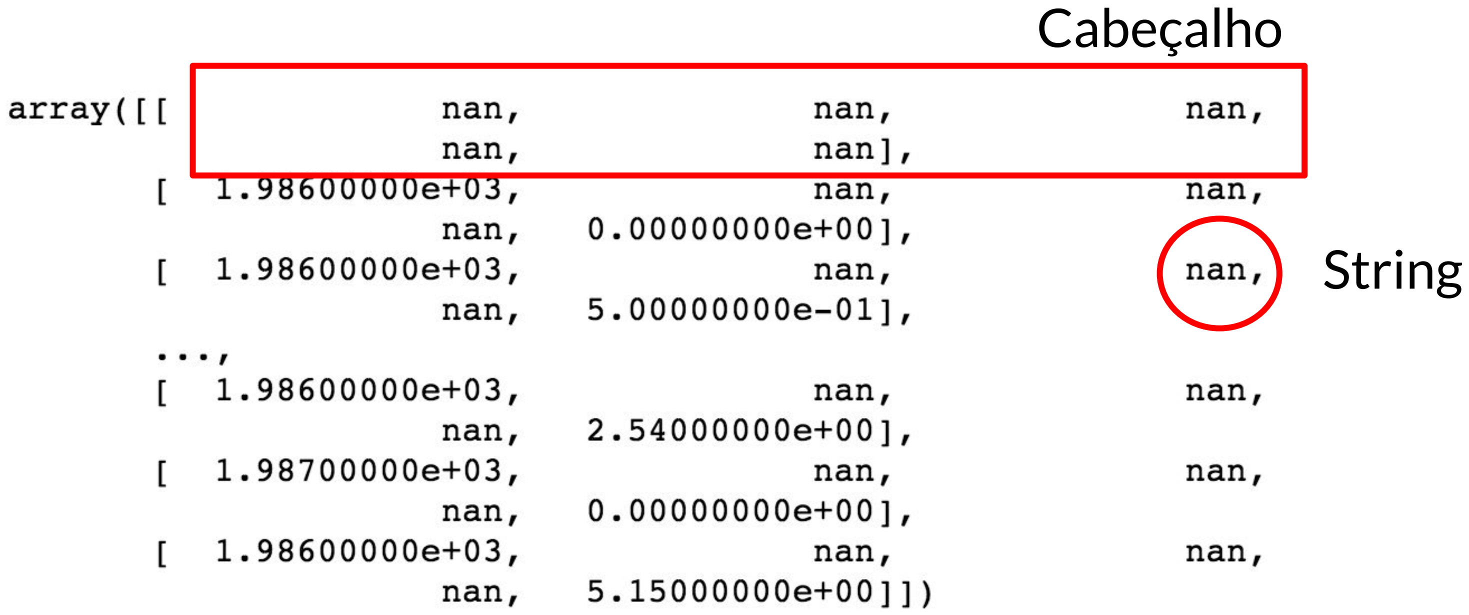
"world_alcohol.csv'

Here's what each column represents:

- Year -- the year the data in the row is for.
- WHO Region -- the region in which the country is located.
- Country -- the country the data is for.
- Beverage Types -- the type of beverage the data is for.
- Display Value -- the number of liters, on average, of the beverage type a citizen of the country drank in the given year.

Inspencionar o conjunto de dados

world_alcohol



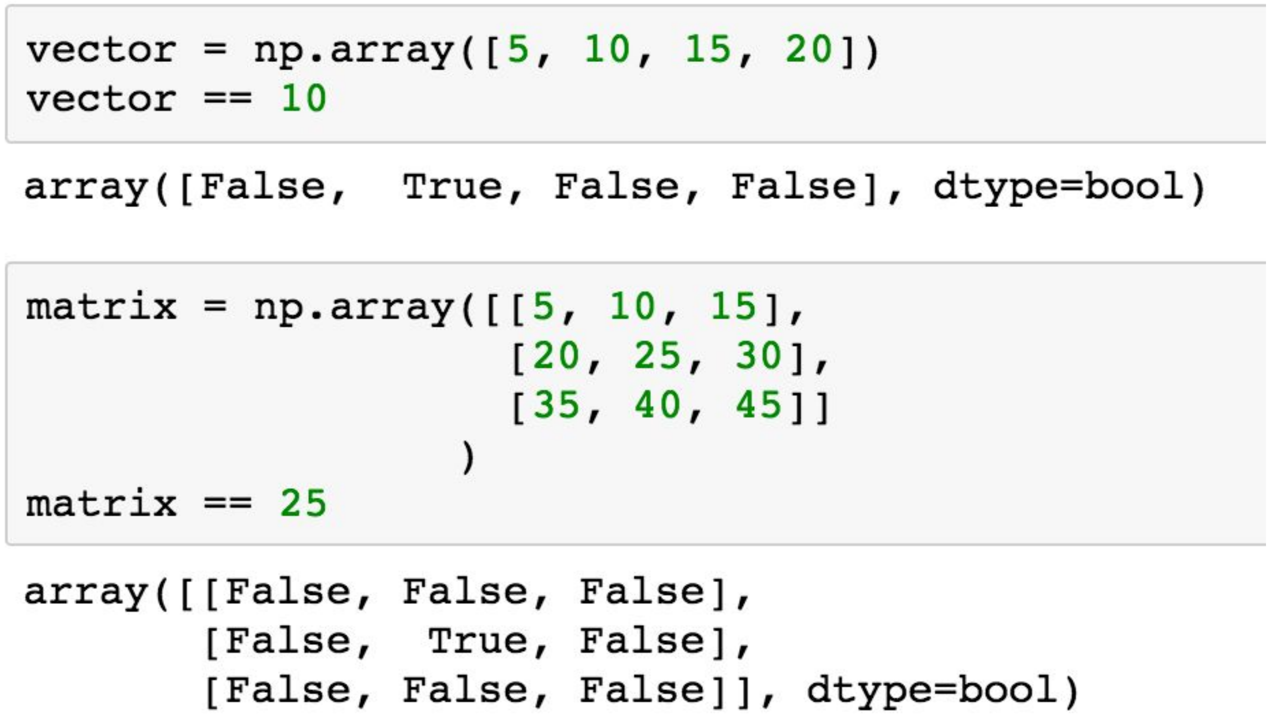
```
array([[                 nan,                  nan,                  nan,
                         nan,                  nan],
       [  1.98600000e+03,                  nan,                  nan,
                         nan,   0.00000000e+00],
       [  1.98600000e+03,                  nan,                  nan,
                         nan,   5.00000000e-01],
       ...,
       [  1.98600000e+03,                  nan,                  nan,
                         nan,   2.54000000e+00],
       [  1.98700000e+03,                  nan,                  nan,
                         nan,   0.00000000e+00],
       [  1.98600000e+03,                  nan,                  nan,
                         nan,   5.15000000e+00]])
```

Quando NumPy é incapaz de transformar o tipo do dado para numérico **(nan)**

Lendo o dado corretamente

```
world_alcohol = np.genfromtxt("world_alcohol.csv", delimiter=",", dtype="U75", skip_head
er=1)
[['1986' 'Western Pacific' 'Viet Nam' 'Wine' '0']
 ['1986' 'Americas' 'Uruguay' 'Other' '0.5']
 ['1985' 'Africa' "Cte d'Ivoire" 'Wine' '1.62']
 ...,
 ['1986' 'Europe' 'Switzerland' 'Spirits' '2.54']
 ['1987' 'Western Pacific' 'Papua New Guinea' 'Other' '0']
 ['1986' 'Africa' 'Swaziland' 'Other' '5.15']]
```

Comparando arrays



```
vector = np.array([5, 10, 15, 20])
vector == 10
```

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

```
matrix = np.array([[5, 10, 15],
                   [20, 25, 30],
                   [35, 40, 45]]
                 )
matrix == 25
```

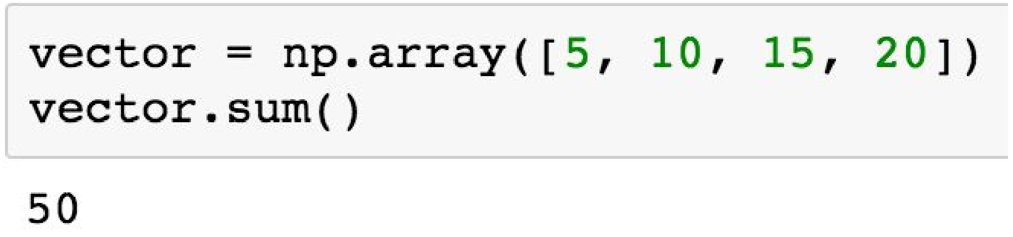
```
array([[False, False, False],
       [False,  True, False],
       [False, False, False]], dtype=bool)
```

Funções agregadas

- sum()
- mean()
- median()
- max()
- min()

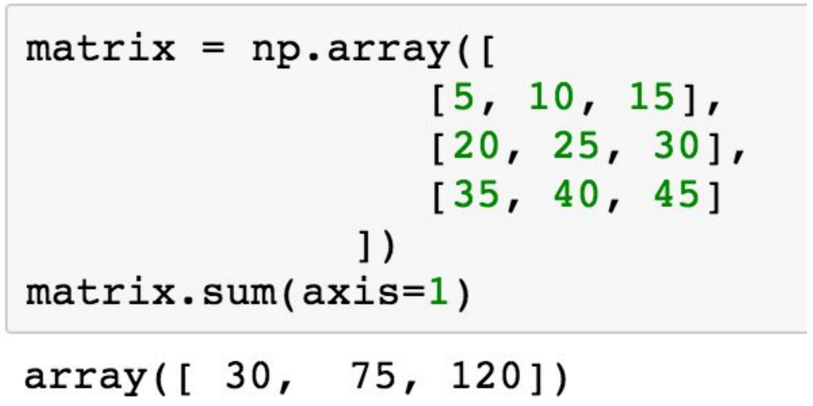
$\}$ Executa funções sobre uma determinada dimensão do array

Funções agregadas



```
vector = np.array([5, 10, 15, 20])
vector.sum()
```

```
50
```



```
matrix = np.array([
                    [5, 10, 15],
                    [20, 25, 30],
                    [35, 40, 45]
                 ])
matrix.sum(axis=1)
```

```
array([ 30,  75, 120])
```

https://goo.gl/0eWPy6

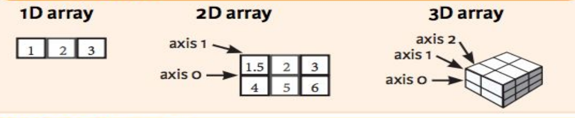
NumPy

The **NumPy** library is the core library for scientific computing in Python. It provides a high-performance multidimensional array object, and tools for working with these arrays.

Use the following import convention:

```
>>> import numpy as np
```

NumPy Arrays



Creating Arrays

```
>>> a = np.array([1,2,3])
>>> b = np.array([(1.5,2,3), (4,5,6)], dtype = float)
>>> c = np.array([[(1.5,2,3), (4,5,6)], [(3,2,1), (4,5,6)]],
                 dtype = float)
```

Initial Placeholders

`>>> np.zeros((3,4))`	Create an array of zeros
`>>> np.ones((2,3,4),dtype=np.int16)`	Create an array of ones
`>>> d = np.arange(10,25,5)`	Create an array of evenly spaced values (step value)
`>>> np.linspace(0,2,9)`	Create an array of evenly spaced values (number of samples)
`>>> e = np.full((2,2),7)`	Create a constant array
`>>> f = np.eye(2)`	Create a 2X2 identity matrix
`>>> np.random.random((2,2))`	Create an array with random values
`>>> np.empty((3,2))`	Create an empty array

I/O

Saving & Loading On Disk

```
>>> np.save('my_array', a)
>>> np.savez('array.npz', a, b)
>>> np.load('my_array.npy')
```

Saving & Loading Text Files

```
>>> np.loadtxt("myfile.txt")
>>> np.genfromtxt("my_file.csv", delimiter=',')
>>> np.savetxt("myarray.txt", a, delimiter=" ")
```

Data Types

`>>> np.int64`	Signed 64-bit integer types
`>>> np.float32`	Standard double-precision floating point
`>>> np.complex`	Complex numbers represented by 128 floats
`>>> np.bool`	Boolean type storing `TRUE` and `FALSE` values
`>>> np.object`	Python object type
`>>> np.string_`	Fixed-length string type
`>>> np.unicode_`	Fixed-length unicode type

Inspecting Your Array

`>>> a.shape`	Array dimensions
`>>> len(a)`	Length of array
`>>> b.ndim`	Number of array dimensions
`>>> e.size`	Number of array elements
`>>> b.dtype`	Data type of array elements
`>>> b.dtype.name`	Name of data type
`>>> b.astype(int)`	Convert an array to a different type

Asking For Help

```
>>> np.info(np.ndarray.dtype)
```

Array Mathematics

Arithmetic Operations

`>>> g = a - b`
`array([[-0.5, 0. , 0. ],`
`[-3. , -3. , -3. ]])`
	Subtraction

`>>> np.subtract(a,b)`	Subtraction

`>>> b + a`
`array([[ 2.5, 4. , 6. ],`
`[ 5. , 7. , 9. ]])`
	Addition

`>>> np.add(b,a)`	Addition

`>>> a / b`
`array([[ 0.66666667, 1. , 1. ],`
`[ 0.25 , 0.4 , 0.5 ]])`
	Division

`>>> np.divide(a,b)`	Division

`>>> a * b`
`array([[ 1.5, 4. , 9. ],`
`[ 4. , 10. , 18. ]])`
	Multiplication

`>>> np.multiply(a,b)`	Multiplication
`>>> np.exp(b)`	Exponentiation
`>>> np.sqrt(b)`	Square root
`>>> np.sin(a)`	Print sines of an array
`>>> np.cos(b)`	Element-wise cosine
`>>> np.log(a)`	Element-wise natural logarithm

`>>> e.dot(f)`
`array([[ 7., 7.],`
`[ 7., 7.]])`
	Dot product

Comparison

`>>> a == b`
`array([[False, True, True],`
`[False, False, False]], dtype=bool)`
	Element-wise comparison

`>>> a < 2`
`array([True, False, False], dtype=bool)`
	Element-wise comparison

`>>> np.array_equal(a, b)`	Array-wise comparison

Aggregate Functions

`>>> a.sum()`	Array-wise sum
`>>> a.min()`	Array-wise minimum value
`>>> b.max(axis=0)`	Maximum value of an array row
`>>> b.cumsum(axis=1)`	Cumulative sum of the elements
`>>> a.mean()`	Mean
`>>> b.median()`	Median
`>>> a.corrcoef()`	Correlation coefficient
`>>> np.std(b)`	Standard deviation

Copying Arrays

`>>> h = a.view()`	Create a view of the array with the same data
`>>> np.copy(a)`	Create a copy of the array
`>>> h = a.copy()`	Create a deep copy of the array

Sorting Arrays

`>>> a.sort()`	Sort an array
`>>> c.sort(axis=0)`	Sort the elements of an array's axis

Subsetting, Slicing, Indexing

Also see Lists

Subsetting

`>>> a[2]`
`3`
		Select the element at the 2nd index

`>>> b[1,2]`
`6.0`
		Select the element at row 0 column 2 (equivalent to `b[1][2]`)

Slicing

`>>> a[0:2]`
`array([1, 2])`
		Select items at index 0 and 1

`>>> b[0:2,1]`
`array([ 2., 5.])`
		Select items at rows 0 and 1 in column 1

`>>> b[:1]`
`array([[1.5, 2., 3.]])`
		Select all items at row 0 (equivalent to `b[0:1, :]`)

`>>> c[1,...]`
`array([[[ 3., 2., 1.],`
`[ 4., 5., 6.]]])`
		Same as `[1,:,:]`

`>>> a[ : :-1]`
`array([3, 2, 1])`
		Reversed array `a`

Boolean Indexing

`>>> a[a<2]`
`array([1])`
		Select elements from `a` less than 2

Fancy Indexing

`>>> b[[1, 0, 1, 0],[0, 1, 2, 0]]`
`array([ 4. , 2. , 6. , 1.5])`
	Select elements `(1,0)`,`(0,1)`,`(1,2)` and `(0,0)`

`>>> b[[1, 0, 1, 0]][:,[0,1,2,0]]`
`array([[ 4. ,5. , 6. , 4. ],`
`[ 1.5, 2. , 3. , 1.5],`
`[ 4. , 5. , 6. , 4. ],`
`[ 1.5, 2. , 3. , 1.5]])`
	Select a subset of the matrix's rows and columns

Array Manipulation

Transposing Array

`>>> i = np.transpose(b)`	Permute array dimensions
`>>> i.T`	Permute array dimensions

Changing Array Shape

`>>> b.ravel()`	Flatten the array
`>>> g.reshape(3,-2)`	Reshape, but don't change data

Adding/Removing Elements

`>>> h.resize((2,6))`	Return a new array with shape (2,6)
`>>> np.append(h,g)`	Append items to an array
`>>> np.insert(a, 1, 5)`	Insert items in an array
`>>> np.delete(a,[1])`	Delete items from an array

Combining Arrays

`>>> np.concatenate((a,d),axis=0)`
`array([ 1, 2, 3, 10, 15, 20])`
	Concatenate arrays

`>>> np.vstack((a,b))`
`array([[ 1. , 2. , 3. ],`
`[ 1.5, 2. , 3. ],`
`[ 4. , 5. , 6. ]])`
	Stack arrays vertically (row-wise)

`>>> np.r_[e,f]`	Stack arrays vertically (row-wise)

`>>> np.hstack((e,f))`
`array([[ 7., 7., 1., 0.],`
`[ 7., 7., 0., 1.]])`
	Stack arrays horizontally (column-wise)

`>>> np.column_stack((a,d))`
`array([[ 1, 10],`
`[ 2, 15],`
`[ 3, 20]])`
	Create stacked column-wise arrays

`>>> np.c_[a,d]`	Create stacked column-wise arrays

Splitting Arrays

`>>> np.hsplit(a,3)`
`[array([1]),array([2]),array([3])]`
	Split the array horizontally at the 3rd index

`>>> np.vsplit(c,2)`
`[array([[[ 1.5, 2. , 1. ],`
`[ 4. , 5. , 6. ]]]),`
`array([[[ 3., 2., 3.],`
`[ 4., 5., 6.]]])]`
	Split the array vertically at the 2nd index

NumPy - Pros & Contra

Pros

- Fácil e flexível para computação científica
- Acesso rápido e flexível ao dado (slicing, indexing)
- Conversão de tipos rapidamente

Contra

- Todos os dados devem ser do mesmo tipo
- Colunas e linhas são acessadas por números

MacBook Pro