An Introduction to Numpy

Data Science 2 / Data & AI 3

KdG Karel de Grote Hogeschool

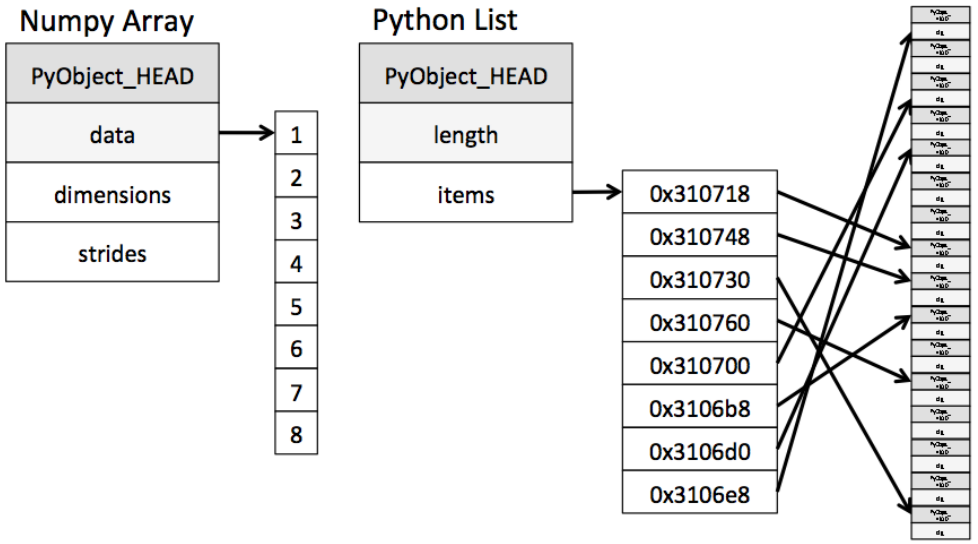
Agenda

1. Introduction
2. Indexing, slicing and reshaping
3. Computation on NumPy Arrays
   - Vectorized operations
   - Agregations
   - Broadcasting
4. Boolean Arrays and Masks
5. Fancy indexing

Introduction

What is Numpy

- NumPy: package for scientific computing in Python
- Python library that provides multidimensional array
- Routines for fast operations on arrays,
  - Mathematical
  - Logical
  - Shape manipulation
  - Selecting
  - Basic linear algebra
  - Basic statistical operations



Array creation

```
# import numpy package
import numpy as np


# Creating Arrays from Python Lists
a = np.array([1, 4, 2, 5, 3])


# Creating Arrays from Scratch
np.zeros(3, dtype=int)                  # array([0, 0, 0])
np.ones((2, 1), dtype=float)            # array([[ 1.],
                                        #        [ 1.]])
np.random.randint(0, 10, (3, 3))        # random integers in [0, 10 )
np.arange(1, 5)                         # [1, 2, 3, 4]
```

Notebook and Exercise time!

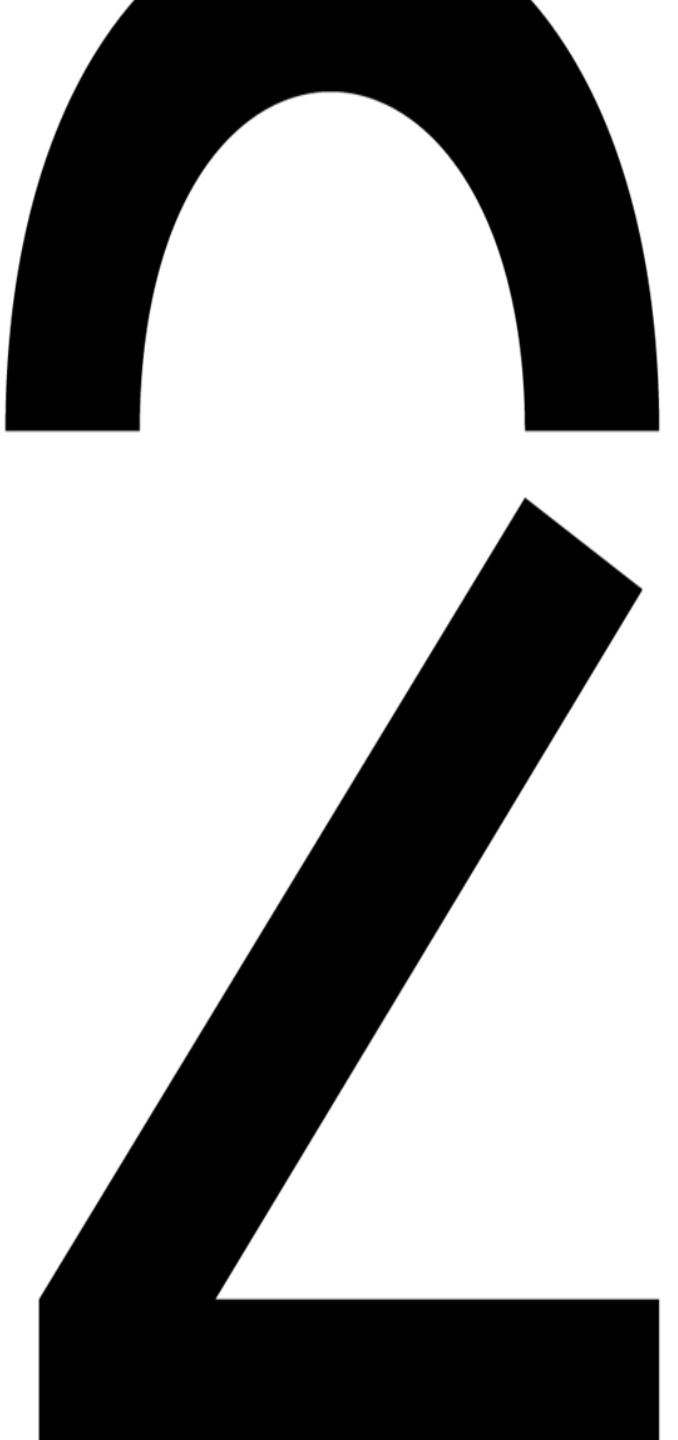
Notebook

See …

Exercise time!

See …

Indexing, slicing and reshaping



Indexing, slicing and reshaping

```
# Array Attributes
x = np.array([[1, 2, 3],
              [4, 5, 6]])
print("x ndim: ", x.ndim)                    # 2
print("x shape:", x.shape)                   # (2, 3), 2 rows and 3 columns
print("x size: ", x.size)                    # 6

# Array Indexing
x[1, 2]                                      # 6
x[0]                                         # [1, 2, 3]
x[-1]                                        # [4, 5, 6]

# Array Slicing
x[0, :2]                                     # [1, 2]
x[:, 1]                                      # [2, 5]
x[:, :2]                                     # [[1, 2], [4, 5]]

# Reshaping
np.arange(1, 10).reshape((3, 3))
```

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Notebook

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Exercise time!

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Computation on NumPy Arrays

Vectorized operations

- Python for loops are slow
- Solution: Numpy's vectorized operations and functions

```
# Array arithmetic
x = np.arange(3)                          # [0, 1, 2]
2 ** x                                    # [1, 2, 4]
x / np.array(1, 4)                        # [0, 0.5, 0.66666667]
-(0.5*x + 1)                              # [-1, -1.5, -2]
np.power(3, x)                            # [1, 3, 9]

# Aggregates
np.add.reduce(x)                          # 3
np.add.accumulate(x)                      # [0, 1, 3]
np.multiply.reduce(x)                     # 0
np.multiply.accumulate(x)                 # [0, 0, 0]
```

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Notebook

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Exercise time!

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Agregations

```
x = np.array([[1, 5, 3],
              [4, 2, 6]])
x.sum                                   # 21
x.min                                   # 1
x.max(axis=0)                           # [1, 2, 3], axis is
dimension that is collapsed
x.max(axis=1)                           # [1, 2]


# Statistics
x.mean(axis=0)                          # [2.5, 3.5, 4.5]
x.var()
x.std(axis=1)
x.var()
x.median()                              # as method
np.median(x)                            # as function
np.percentile(x, 25)
```

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Notebook

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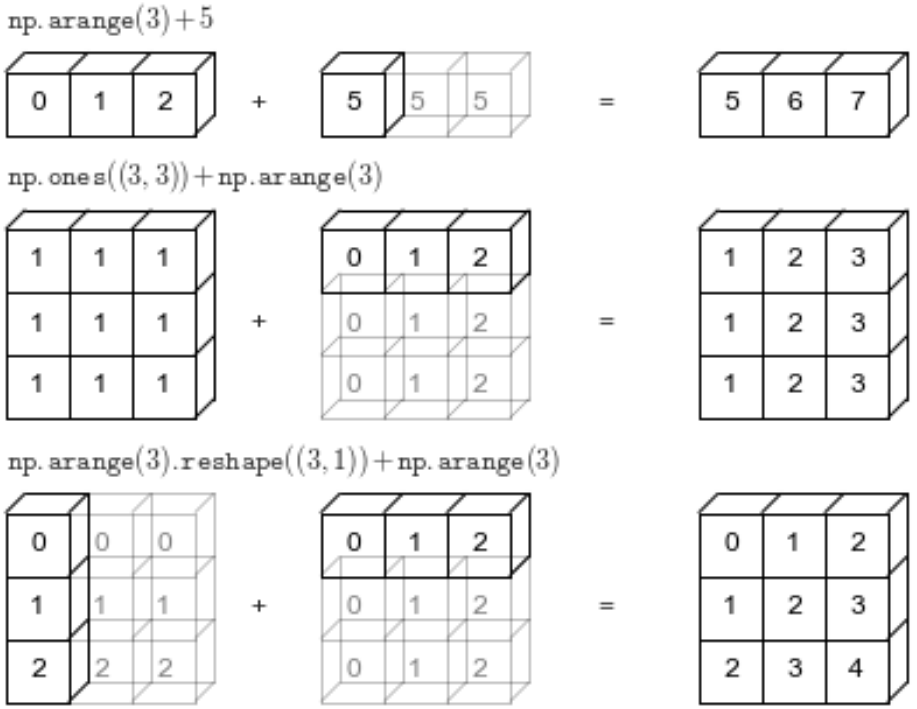
Broadcasting

Rules

1. If the two arrays differ in their number of dimensions, the shape of the one with fewer dimensions is padded with ones on its leading (left) side
2. If the shape of the two arrays does not match in any dimension, the array with shape equal to 1 in that dimension is stretched to match the other shape
3. If in any dimension the sizes disagree and neither is equal to 1 -> error



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Boolean Arrays and Masks

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Boolean Arrays and Masks

```
x = np.array([[1, 5, 3],
              [4, 2, 6]])
x < 5                                   # [[True,
False, True], [True, True, False]]
np.sum(x < 5)                           # 4, False -> 0, True ->
1
np.sum(x < 5, axis=1)                   # [2, 2]
np.any(x < 5)                           # True
np.all(x < 5)                           # False
np.sum((x > 2) & (x < 5))               # 2

# Boolean Arrays as Masks
x[x < 5]                                # [1, 3, 4, 2], returns
1-dim array
```

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Notebook

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Fancy indexing

Fancy indexing

```
x = np.arange(1,10)
ind = [3, 7, 4, 0]
x[ind]                                  # [4, 8, 5, 1]
```

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Notebook

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