

Bootcamp

Python



Day03 - NumPy

Today you will learn how to use the Python library that will allow you to manipulate multidimensional arrays and perform complex mathematical operations on matrices.

Notions of the day

NumPy array, slicing, stacking, dimensions, broadcasting, normalization, etc...

General rules

- Use the NumPy Library : use NumPy's built-in functions as much as possible. Here you will be given no credit for reinventing the wheel.
- The version of python to use is 3.7, you can check the version of python with the following command: `python -v`
- The norm: during this bootcamp you will follow the Pep8 standards <https://www.python.org/dev/peps/pep-0008/>
- The function eval is never allowed.
- The exercices are ordered from the easiest to the hardest.
- Your exercices are going to be evaluated by someone else so make sure that variables and functions names are appropriated.
- Your man is internet.
- You can also ask question in the dedicated channel in Slack: 42-ai.slack.com.
- If you find any issue or mistakes in the subject please create an issue on our dedicated repository on Github: https://github.com/42-AI/bootcamp_python/issues.

Helper

For this day you will use the image provided at the root in the resources folder.

Exercise 00 - NumPyCreator

Exercise 01 - ImageProcessor

Exercise 02 - Basic manipulations

Exercise 03 - Color filters

Exercise 04 - Advanced modifications

Exercise 00 - NumPyCreator

| | |
|---------------------|-----------------|
| Turnin directory : | ex00 |
| Files to turn in : | NumPyCreator.py |
| Allowed Libraries : | numpy |
| Remarks : | n/a |

You need to write a class named NumPyCreator, which will implement all of the following methods.

Each method receives as an argument a different type of data structure and transforms it into a NumPy array :

- **from_list(lst)** : takes in a list and returns its corresponding NumPy array.
- **from_tuple(tpl)** : takes in a tuple and returns its corresponding NumPy array.
- **from_iterable(itr)** : takes in an iterable and returns an array which contains all of its elements.
- **from_shape(shape, value)** : returns an array filled with the same value.
The first argument is a tuple which specifies the shape of the array, and the second argument specifies the value of all the elements. This value must be 0 by default.
- **random(shape)** : returns an array filled with random values.
It takes as an argument a tuple which specifies the shape of the array.
- **identity(n)** : returns an array representing the identity matrix of size n.

BONUS : Add to those methods an optional argument which specifies the dtype of the array (e.g. if you want its elements to be represented as integers, floats, ...)

NOTE : All those methods can be implemented in one line. You only need to find the right NumPy functions.

```
>>> from NumPyCreator import NumPyCreator
>>> npc = NumPyCreator()
>>> npc.from_list([[1,2,3],[6,3,4]])
array([[1, 2, 3],
       [6, 3, 4]])
>>> npc.from_tuple(("a", "b", "c"))
array(['a', 'b', 'c'])
>>> npc.from_iterable(range(5))
array([0, 1, 2, 3, 4])
>>> shape=(3,5)
>>> npc.from_shape(shape)
```

```
array([[0, 0, 0, 0, 0],
       [0, 0, 0, 0, 0],
       [0, 0, 0, 0, 0]])
>>> np.random(shape)
array([[0.57055863, 0.23519999, 0.56209311, 0.79231567, 0.213768 ],
       [0.39608366, 0.18632147, 0.80054602, 0.44905766, 0.81313615],
       [0.79585328, 0.00660962, 0.92910958, 0.9905421 , 0.05244791]])
>>> np.identity(4)
array([[1., 0., 0., 0.],
       [0., 1., 0., 0.],
       [0., 0., 1., 0.],
       [0., 0., 0., 1.]])
```

Exercise 01 - ImageProcessor

| | |
|----------------------|------------------|
| Turnin directory : | ex01 |
| Files to turn in : | ImageProcesor.py |
| Forbidden function : | None |
| Helpful libraries : | Matplotlib |

Now you will build a tool that you will use in the upcoming exercises to load and display images.

Write a class named ImageProcessor which implements the following methods:

- **load(path)** : opens the .png file specified by the **path** argument and returns an array with the RGB values of the image pixels.
It must display a message specifying the dimensions of the image (e.g. 340 x 500).
- **display(array)** : takes a NumPy array as an argument and displays the corresponding RGB image.

NOTE : You can use any library you want for this exercise, but you must convert the image to a NumPy array. The goal of this exercise is to dispense with the technicality of loading and displaying images, so that you can focus on array manipulation in the upcoming exercises.

```
>>> from ImageProcessor import ImageProcessor
>>> imp = ImageProcessor()
>>> arr = imp.load("../resources/42AI.png")
Loading image of dimensions 200 x 200
>>> arr
array([[0.03529412, 0.12156863, 0.3137255 ],
       [0.03921569, 0.1254902 , 0.31764707],
       [0.04313726, 0.12941177, 0.3254902 ],
       ...,
       [0.02745098, 0.07450981, 0.22745098],
       [0.02745098, 0.07450981, 0.22745098],
       [0.02352941, 0.07058824, 0.22352941]],
      [[0.03921569, 0.11764706, 0.30588236],
       [0.03529412, 0.11764706, 0.30980393],
       [0.03921569, 0.12156863, 0.30980393],
       ...,
       [0.02352941, 0.07450981, 0.22745098],
       [0.02352941, 0.07450981, 0.22745098],
```

```
[0.02352941, 0.07450981, 0.22745098]],  
[[0.03137255, 0.10980392, 0.2901961 ],  
[0.03137255, 0.11372549, 0.29803923],  
[0.03529412, 0.11764706, 0.30588236],  
...,  
[0.02745098, 0.07450981, 0.23137255],  
[0.02352941, 0.07450981, 0.22745098],  
[0.02352941, 0.07450981, 0.22745098]],  
...,  
[[0.03137255, 0.07450981, 0.21960784],  
[0.03137255, 0.07058824, 0.21568628],  
[0.03137255, 0.07058824, 0.21960784],  
...,  
[0.03921569, 0.10980392, 0.2784314 ],  
[0.03921569, 0.10980392, 0.27450982],  
[0.03921569, 0.10980392, 0.27450982]],  
[[0.03137255, 0.07058824, 0.21960784],  
[0.03137255, 0.07058824, 0.21568628],  
[0.03137255, 0.07058824, 0.21568628],  
...,  
[0.03921569, 0.10588235, 0.27058825],  
[0.03921569, 0.10588235, 0.27058825],  
[0.03921569, 0.10588235, 0.27058825]],  
[[0.03137255, 0.07058824, 0.21960784],  
[0.03137255, 0.07058824, 0.21176471],  
[0.03137255, 0.07058824, 0.21568628],  
...,  
[0.03921569, 0.10588235, 0.26666668],  
[0.03921569, 0.10588235, 0.26666668],  
[0.03921569, 0.10588235, 0.26666668]]], dtype=float32)  
>>> imp.display(arr)
```

Exercise 02 - ScrapBooker

| | |
|---------------------|----------------|
| Turnin directory : | ex02 |
| Files to turn in : | ScrapBooker.py |
| Allowed libraries : | NumPy |
| Notions : | Slicing |

Write a class named ScrapBooker which implements the following methods.

All methods take in a NumPy array and return a new modified one.

We are assuming that all inputs are right, you don't have to protect your functions.

- **crop(array, dimensions, position)** : crop the image as a rectangle with the given **dimensions** (it's the new image size), whose top left corner is given by the **position** argument. The position should be (0,0) by default. You have to handle error if dimensions is larger than the current image size.
- **thin(array, n, axis)** : delete every n-th pixel row along the specified axis (0 vertical, 1 horizontal), example below.
- **juxtapose(array, n, axis)** : juxtapose **n** copies of the image along the specified axis (0 vertical, 1 horizontal).
- **mosaic(array, dimensions)** : make a grid with multiple copies of the array. The **dimensions** (it's the size of the grid) argument specifies the dimensions of the grid (e.g. 2x3).

NOTE : In this exercise, when specifying positions or dimensions, we will assume that the first coordinate is counted along the vertical axis starting from the TOP, and that the second coordinate is counted along the horizontal axis starting from the left. Indexing starts from 0.

e.g.:

(1,3)

.....

...x.

.....

example for thin:

```
permorm thin with n=3 and axis=0:  
ABCDEFGHIJQL      ABDEGHJQ  
ABCDEFGHIJQL      ABDEGHJQ  
ABCDEFGHIJQL      ABDEGHJQ  
ABCDEFGHIJQL      ABDEGHJQ  
ABCDEFGHIJQL      ABDEGHJQ  
ABCDEFGHIJQL ==> ABDEGHJQ
```

```
ABCDEFGHIJQL      ABDEGHJQ
ABCDEFGHIJQL      ABDEGHJQ
ABCDEFGHIJQL      ABDEGHJQ
ABCDEFGHIJQL      ABDEGHJQ
ABCDEFGHIJQL      ABDEGHJQ
permorm thin with n=4 and axis=1:
AAAAAAAAAAAAA
BBBBBBBBBBBBB    AAAAAAAA
CCCCCCCCCCCCC    BBBBBBBBBB
DDDDDDDDDDDDD    CCCCCCCCCCCC
EEEEEEEEE      EEEEEEEEEE
FFFFFFFFFFFF ==> FFFFFFFFFF
GGGGGGGGGGGGG    GGGGGGGGGGGG
HHHHHHHHHHHHH    IIIIIIIIII
IIIIIIIIII      JJJJJJJJJJJJ
JJJJJJJJJJJJ    KKKKKKKKKKKK
KKKKKKKKKKKK
LLLLLLLLLLL
```

Exercise 03 - ColorFilter

| | |
|----------------------|-----------------|
| Turnin directory : | ex03 |
| Files to turn in : | ColorFilter.py |
| Forbidden function : | See each method |
| Notions : | broadcasting |

Now you will build a tool that can apply a variety of color filters on images.
For this exercise, the authorized functions and operators are specified for each methods. You are not allowed to use anything else.

Write a class named ColorFilter which implements the following methods:

- **invert(array)** : Takes a NumPy array of an image as an argument and returns an array with inverted color.

Authorized function : None

Authorized operator: -

- **to_blue(array)** : Takes a NumPy array of an image as an argument and returns an array with a blue filter.

Authorized function : .zeros, .shape

Authorized operator: None

- **to_green(array)** : Takes a NumPy array of an image as an argument and returns an array with a green filter.

Authorized function : None

Authorized operator: *

- **to_red(array)** : Takes a NumPy array of an image as an argument and returns an array with a red filter.

Authorized function : green, blue

Authorized operator: -, +

- **celluloid(array)** : Takes a NumPy array of an image as an argument, and returns an array with a celluloid shade filter.

The celluloid filter must display at least four thresholds of shades. Be careful! You are not asked to apply black contour on the object here (you will have to, but later...), you have only to work on the shades of your images.

Authorized function: arange, linspace

Bonus: add an argument to your method to let the user choose the number of thresholds.

Authorized function : .vectorize, (.arange?)

Authorized operator: None

- **to_grayscale(array, filter)** : Takes a NumPy array of an image as an argument and returns an array in grayscale. The method takes another argument to select between two possible grayscale filters. Each filter has specific authorized functions and operators.

* 'mean' or 'm' : Takes a NumPy array of an image as an argument and returns an array in grayscale created from the mean of the RGB channels.

Authorized function : .sum, .shape, reshape, broadcast_to, (as_type?)

Authorized operator: /

* 'weighted' or 'w' : Takes a NumPy array of an image as an argument and returns an array in weighted grayscale. This argument should be selected by default if not given.

The usual weighted grayscale is calculated as : $0.299 * R_channel + 0.587 * G_channel + 0.114 * B_channel$.

Authorized function : .sum, .shape, .tile

Authorized operator: *

```
>>> from ImageProcessor import ImageProcessor
>>> imp = ImageProcessor()
>>> arr = imp.load("../42AI.png")
Loading image of dimensions 200 x 200
>>> from ColorFilter import ColorFilter
>>> cf = ColorFilter()
>>> cf.invert(arr)
>>>
>>> cf.to_green(arr)
>>>
>>> cf.to_red(arr)
>>>
>>> cf.to_blue(arr)
>>>
>>> cf.to_celluloid(arr)
>>>
>>> cf.to_grayscale(arr, 'm')
>>>
>>> cf.to_grayscale(arr, 'weigthed')
>>>
```

Exercise 04 - AdvancedFilter

| | |
|---------------------|----------------------------|
| Turnin directory : | ex04 |
| Files to turn in : | AdvancedFilter.py |
| Allowed libraries : | NumPy |
| Notions : | Slicing, matrix operations |

Write a class named AdvancedFilter which implements the following methods.
All methods take in a 3d NumPy array and return a modified copy of the array.

The following video should be used as a resource for completing the exercise:
https://www.youtube.com/watch?v=C_zFhWdM4ic

- **mean.blur()** : This method receives an image, performs a mean blur on it and returns a blurred copy. In a mean blur, each pixel becomes the average of its neighboring pixels.
- **gaussian.blur()** : This method receives an image, performs a gaussian blur on it and returns a blurred copy. In a gaussian blur, the weighting of the neighboring pixels is adjusted so that closer pixels are more heavily counted in the average.

BONUS : You can add an optional argument to those methods to choose the kernel size.

Remember, you can add helper methods to your class!