Introduction to Numerical Computing in Python

Ing. Alexander Sierra

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Vectorized Computation

Numpy is the fundamental package for high-performance scientific computing and data analysis. It provides a powerful **ndarray** object, which is a fast and space-efficient multidimensional array providing vectorized arithmetic operations and sophisticated broadcasting capabilities. Numpy enable you to perform mathematical operations on whole blocks of data using similar syntax to the equivalent operations between scalar elements.
In particular, you will be provided with a real-world problems and be asked to provide a solution using NumPy.

Problem 1

Consider a 1-dimensional ndarray of **True** and **False** objects. The problem states that you should:

- count the number of False-to-True transitions in the sequence.
- find all the indices where the False-to-True transitions occurs.

```
import numpy as np

rnd_seq = np.random.choice([True, False], 100000)

# TODO: add your code here
```

Script 1: random sequence of boolean objects

Problem 2

Consider a 2-dimensional ndarray containing the 3D point cloud coordinates. Where N is the number of points. All data is saved in **pointCloud.csv** file. The first line of file is a header that contains column labels followed by the rows of data. Each row of array contains the (x, y, z) coordinates of each point.

$$\begin{bmatrix} x_1 & y_1 & z_1 \\ x_2 & y_2 & z_2 \\ \vdots & \vdots & \vdots \\ x_N & y_N & z_N \end{bmatrix} \tag{1}$$

In Figure 1, we can see an example of a point cloud.

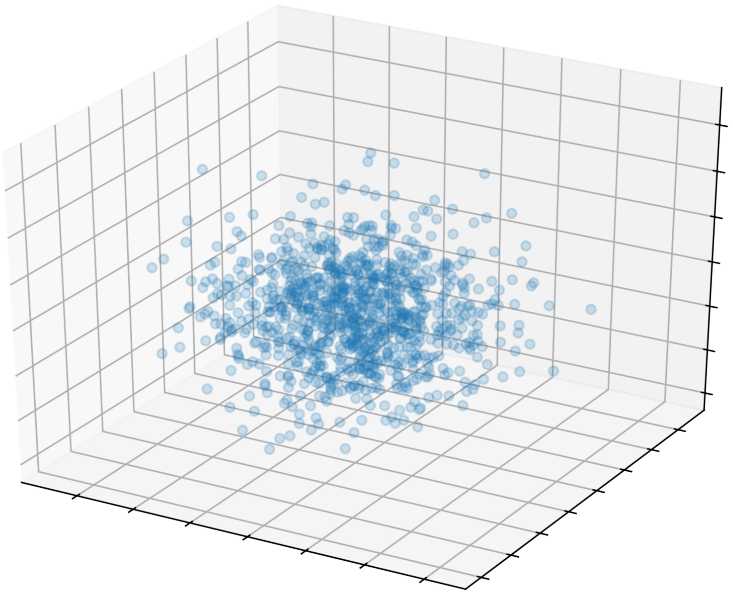

Figure 1: 3D Point Cloud

The problem states that you should:

- Compute the average Euclidean distance from origin to point cloud.

First of all, You should handle the missing values.

```
import numpy as np

filename = "pointCloud.csv"

# TODO: add your code here
```

Script 2: 3D point cloud

Problem 3

The **CoR_coordinates.csv** file specify the position of two points in the three-dimensional space at different times. A fragment of this file is shown in the table below.

Table 1: coordinates of each point

rcorx	rcory	rcorz	lcorx	lcory	lcorz
$rcorx_1$	$rcory_1$	$rcorz_1$	$lcorx_1$	$lcory_1$	$lcorz_1$
$rcorx_2$	$rcory_2$	$rcorz_2$	$lcorx_2$	$lcory_2$	$lcorz_2$
$rcorx_3$	$rcory_3$	$rcorz_3$	$lcorx_3$	$lcory_3$	$lcorz_3$
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
$rcorx_N$	$rcory_N$	$rcorz_N$	$lcorx_N$	$lcory_N$	$lcorz_N$

The first line of file is a header that contains column labels followed by the rows of data. Each row of data contains the (x, y, z) coordinates of each point.

The problem states that you should:

- compute the average Euclidean distance between two points.
- compute the average velocity of the midpoint between them. As the sampling rate was 100 Hz, the time between 2 frames is equivalent to 10 ms.

```python
import numpy as np

filename = "CoR_coordinates.csv"

# TODO: add your code here
```

Script 3: 3D point cloud

Marking criteria

The assignment is marked out of 50. Your work will be marked using the following criteria:

- Problem 1, 10 marks.
- Problem 2, 20 marks.
- Problem 3, 20 marks.

Important dates

Hand-out date: 14$^{\text{th}}$ Sep. 2021, 22:00
Hand-out Method: Moodle and Microsoft Teams

Hand-in date: 17$^{\text{th}}$ Sep. 2021, 18:00
Hand-in Method: Moodle