

# Agenda

- Sorting
- Matrix multiplication
  - `np.dot`
  - `@`
  - `np.matmul`
- Vectorization
- Broadcasting

## Sorting

- ① `sort` method (oop) `list.sort`
  - Inplace Operation

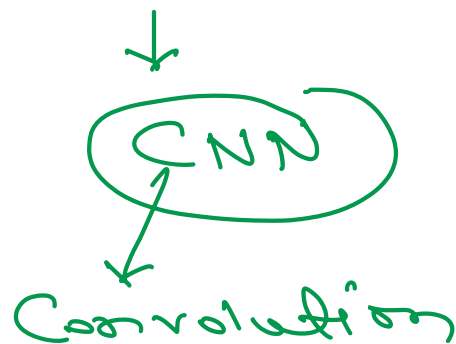
- ② `sorted` function
    - `x` Inplace operation
- Diagram illustrating the relationship between `sorted` and `np.sort`:
- ```
graph TD; A[sorted function] --> B[np.sort]; B --> C["x inplace"]
```

# Matrix multiplication

① Two matrices : Element wise

$$\begin{bmatrix} 1 & 5 \\ 3 & 4 \end{bmatrix} \times \begin{bmatrix} 2 & 1 \\ 1 & 2 \end{bmatrix} \Rightarrow \begin{bmatrix} 2 & 2 \\ 3 & 8 \end{bmatrix}$$

② Computer Vision



② Matrix  $\times$  Scalar = S

$$\begin{bmatrix} 1 & 5 \\ 3 & 4 \end{bmatrix} \times 5 \Rightarrow \begin{bmatrix} 5 & 10 \\ 15 & 20 \end{bmatrix}$$

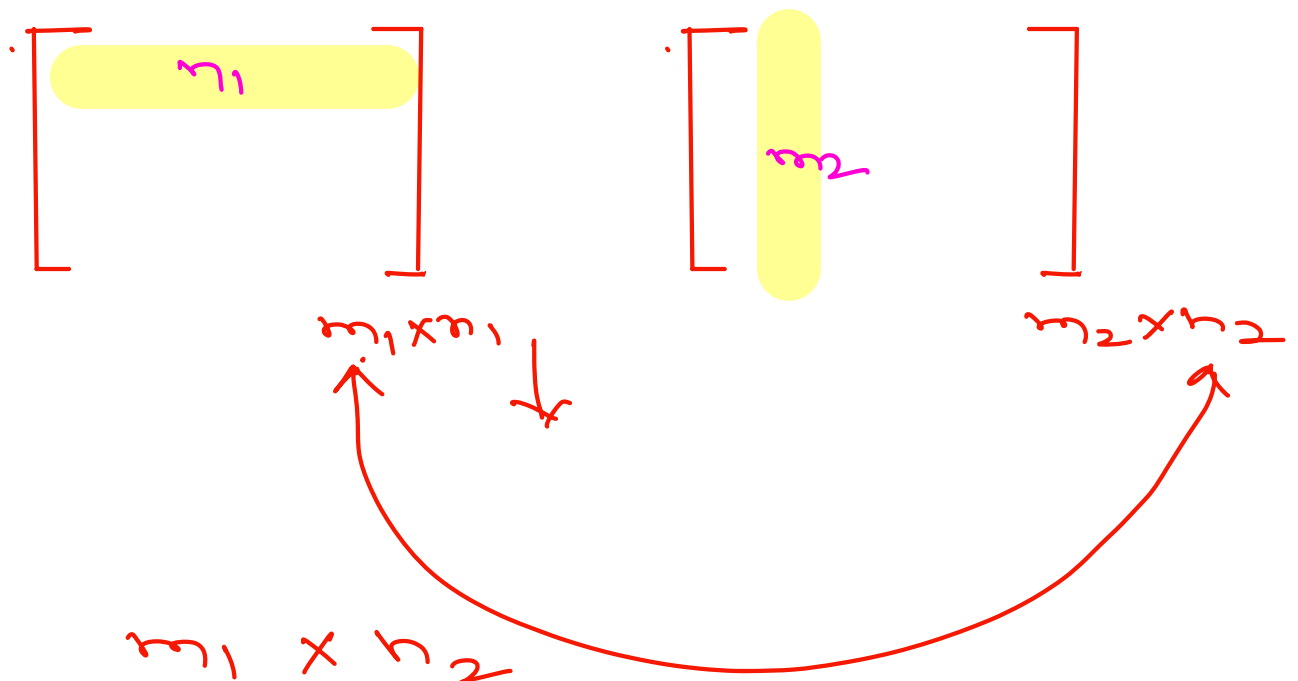
$$\textcircled{2} \begin{bmatrix} \textcircled{1} & \textcircled{5} \\ \textcircled{3} & \textcircled{4} \end{bmatrix} \times \begin{bmatrix} 5 & 5 \\ 5 & 5 \end{bmatrix} \nearrow$$

(Element wise)

$\textcircled{3}$  Standard Matrix Multiplication

$$\begin{array}{ccc} Q_1 \textcircled{1} & m_1 \times & n_1 \\ Q_2 \textcircled{1} & m_2 \times & n_2 \end{array}$$

$$Q_1 \times Q_2 \textcircled{1} \quad m_1 = m_2$$



# Broadcasting

|    |    |    |
|----|----|----|
| 0  | 0  | 0  |
| 10 | 10 | 10 |
| 20 | 20 | 20 |
| 30 | 30 | 30 |

+

|   |   |   |
|---|---|---|
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 0 | 1 | 2 |

=

|    |    |    |
|----|----|----|
| 0  | 0  | 0  |
| 10 | 10 | 10 |
| 20 | 20 | 20 |
| 30 | 30 | 30 |

+

|   |   |   |
|---|---|---|
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 0 | 1 | 2 |

$4 \times 3$

L

$4 \times 3$

=

H

$4 \times 3$

$4 \times 3$

a

|    |    |    |
|----|----|----|
| 0  | 0  | 0  |
| 10 | 10 | 10 |
| 20 | 20 | 20 |
| 30 | 30 | 30 |

+

b

|   |   |   |
|---|---|---|
| 0 | 1 | 2 |
|---|---|---|

=

|    |    |    |
|----|----|----|
| 0  | 0  | 0  |
| 10 | 10 | 10 |
| 20 | 20 | 20 |
| 30 | 30 | 30 |

+

|   |   |   |
|---|---|---|
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 0 | 1 | 2 |
| 0 | 1 | 2 |

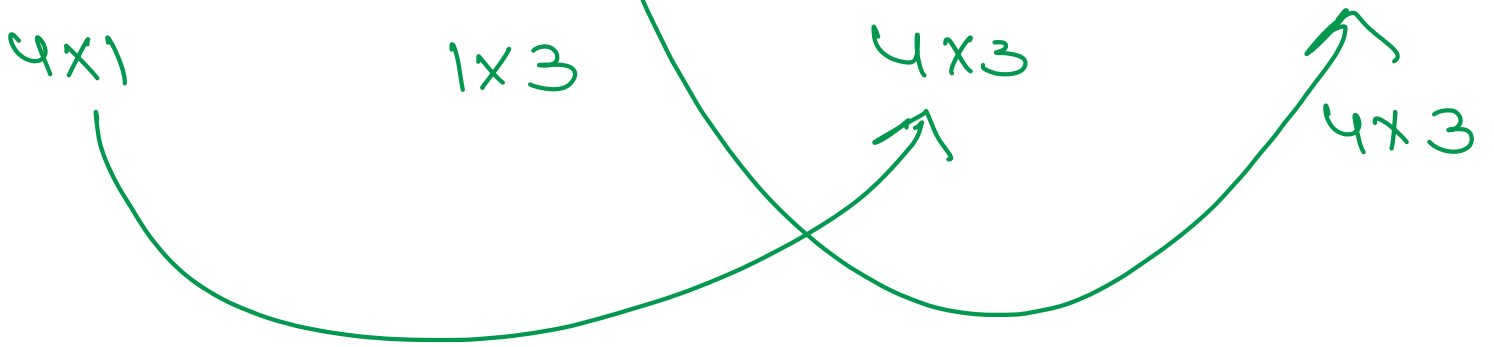
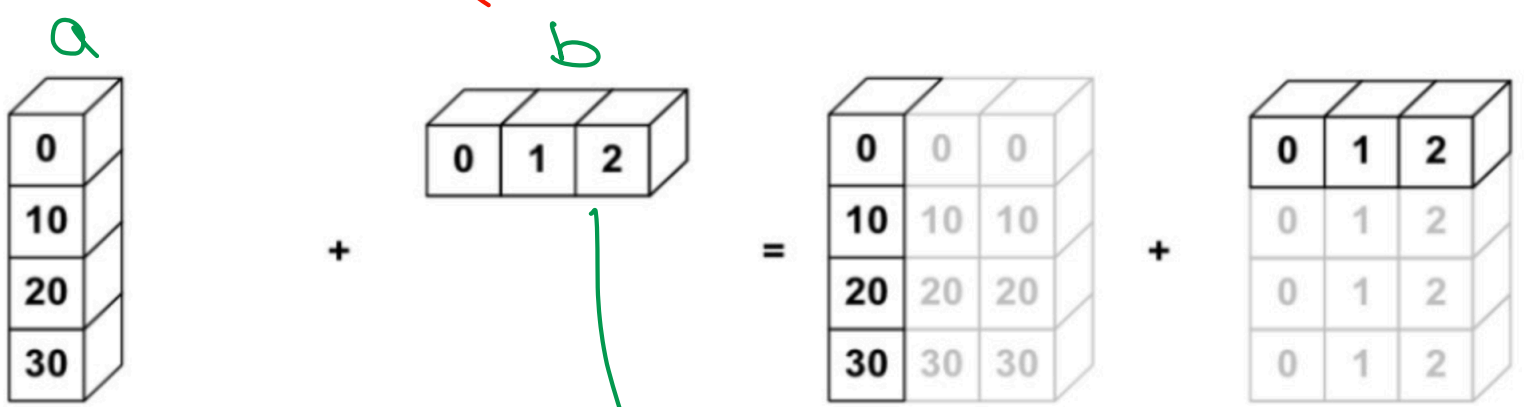
$4 \times 3$

$1 \times 3$

$4 \times 3$

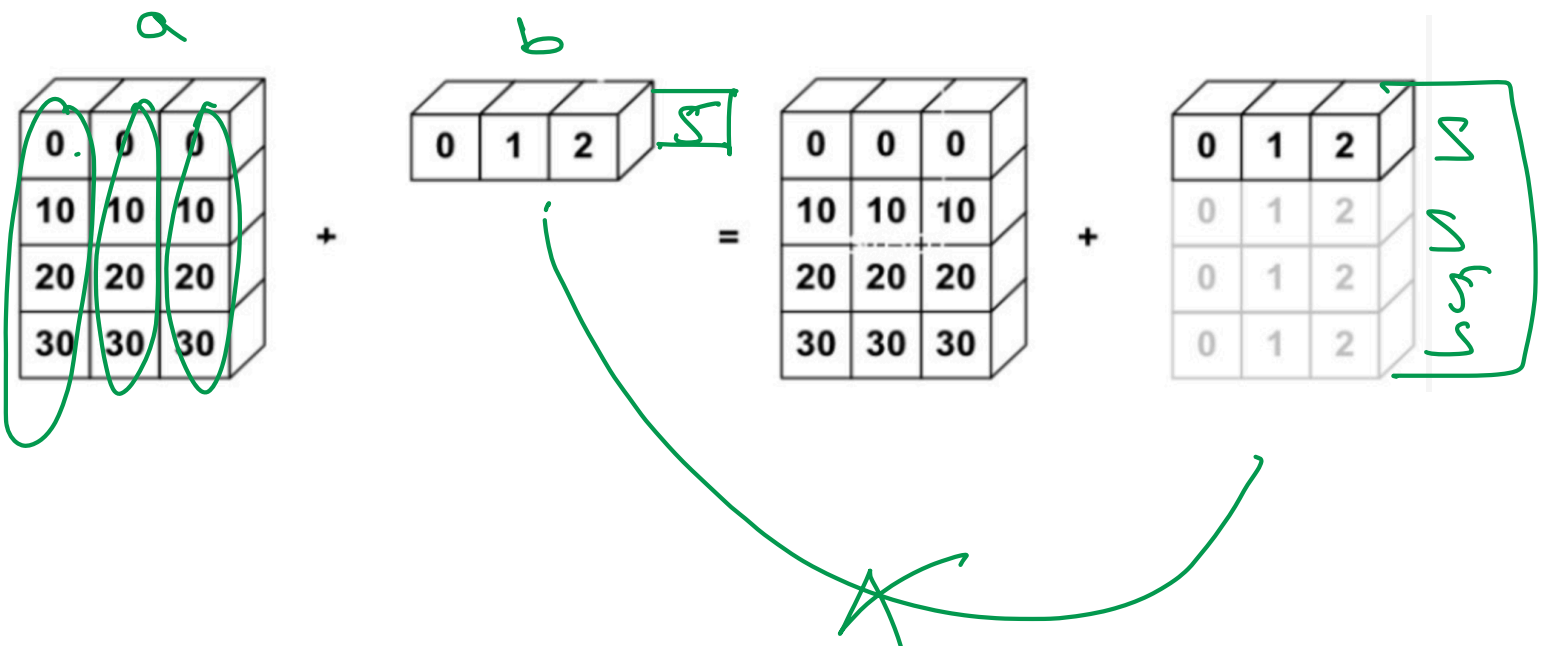
L.H.S = R.H.S

(Broadcasting)



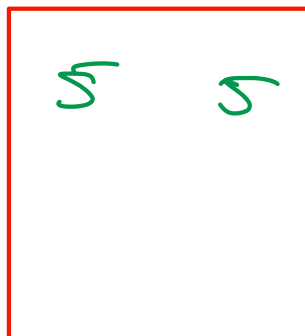
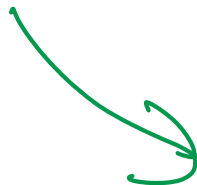
$1 \times$

~~XXXX~~





~~5~~



5

5



0

-5 → -1

arr [-5, -1, -1]

row

col

-5 : -1 : -1

