01_CV_UE

① Plot an image in Python

see notebook

② Convolution

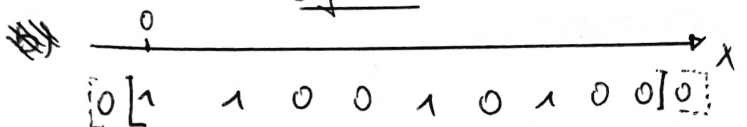
a) Commutative property

$$(h * f)[x] = \sum_{i=0}^{N-1} h_i f_{x-i} = \sum_{i=x}^{N-1+x} h_{i-x} f_{-i} = \sum_{i=x-(N-1)}^{x} h_{i-x+(N-1)} f_{-i+(N-1)}$$

$$\text{p.b.c} = \sum_{i=0}^{N-1} h_{-(i-x)} f_{-(-i)} = \sum_{i=0}^{N-1} h_{x-i} f_i = (f * h)[x]$$

b) Boundary conditions

signal



□ ≙ signal
□ ≙ signal + zero padding

h[x] = [1 0 1]

result

"valid" [1 1 -1 0 0 0 1]

zero-padding [-1 1 1 -1 0 0 0 1 0]

c) Implementation

see notebook

d) Separable kernels

naive: • 9 x 25 x 25 kernel ≙ { 9·25·25 Multiplications ; 9·25·25 − 1 Additions } times 100·800·800 image pts

≙ { $36 \cdot 10^{10}$ Multiplications ; $35{,}9 \cdot 10^{10}$ Additions }

separable: • 9x1x1 * 1x25x1 * 1x1x25 kernel

≙ { 9+25+25 Multiplications ; (9−1)+(25−1)+(25−1) Additions } times (100·800·800) image pts. ≙ { $3{,}8 \cdot 10^9$ Mult. ; $3{,}6 \cdot 10^9$ Add. }

③, ④, ⑤ see notebook