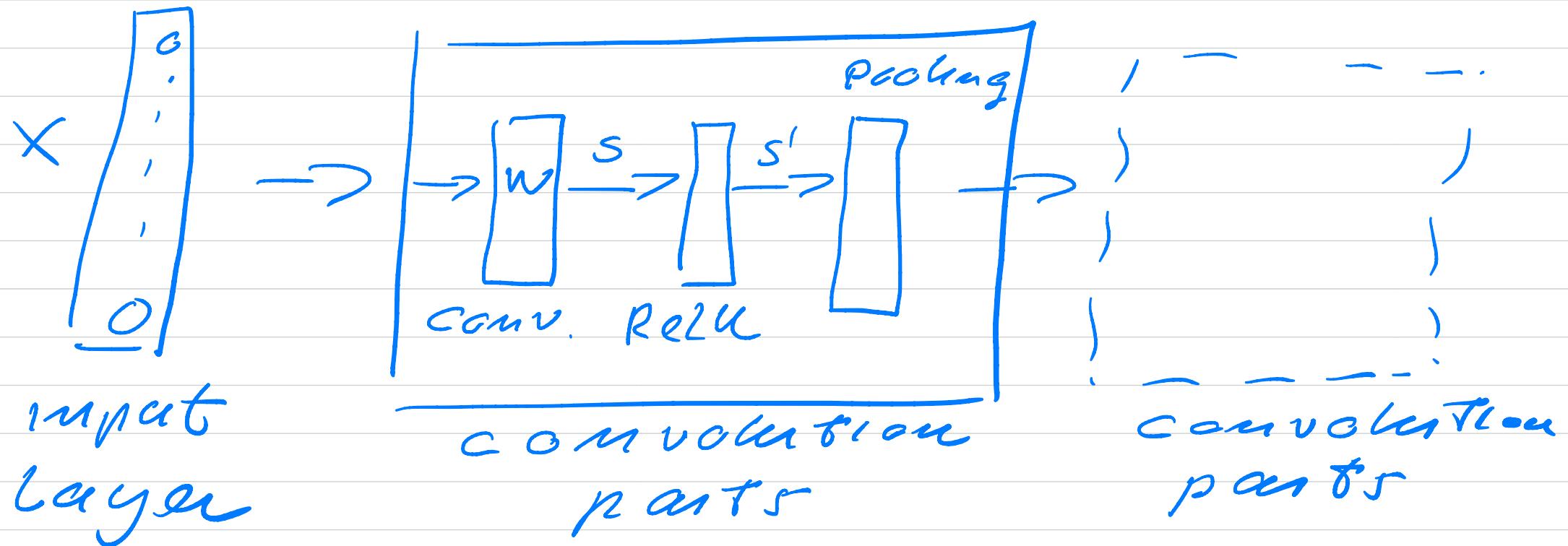


**Erasmus+ course on
Machine Learning,
December 18, 2023**

BASIC Layout of a CNN



Fully connected

Normally
a standard
FFNN

act
perf

cast

targets

output from conv $S = \overline{I} * W$
 (K)

I

a	b	c	d
e	f	g	h
i	j	k	l

W

w	x
y	z

Stride $= 1$

3×4

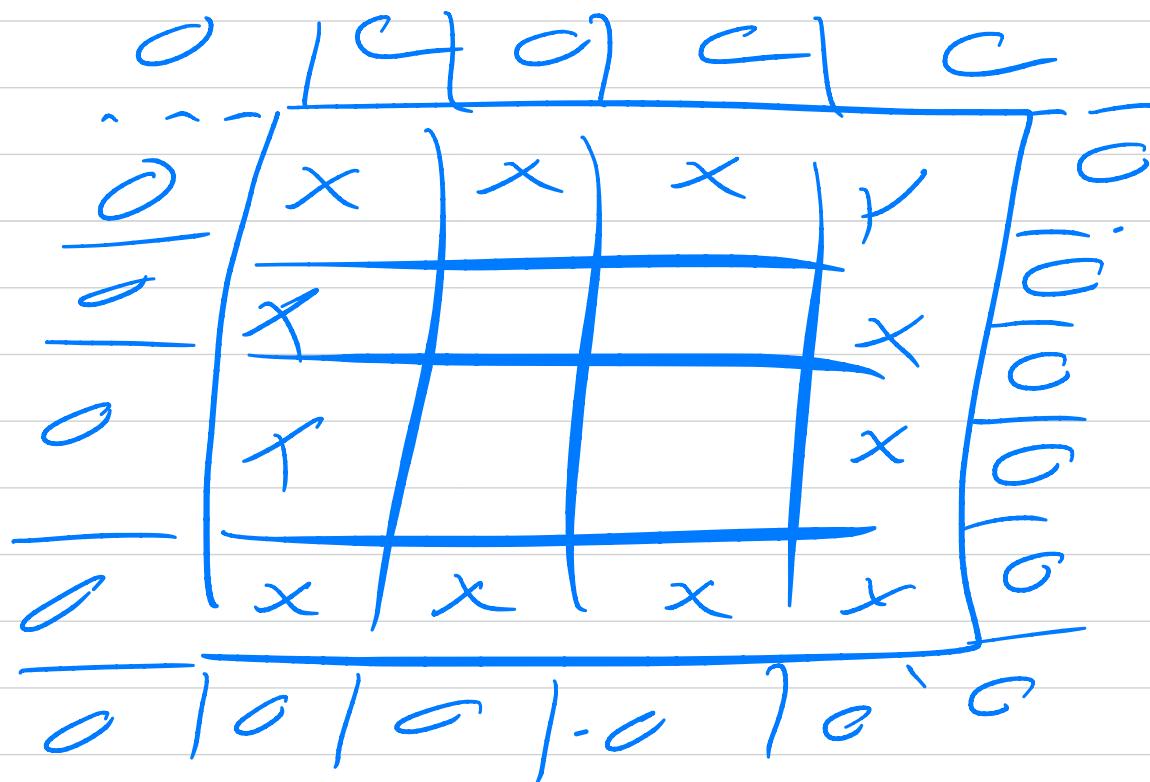
$\overline{I} * W =$

2×3

$aw + bx$ $+ ey + fz$	$bw + cx$ $+ fy + gz$	$cw + dx$ $+ gy + hz$
$ew +$ $fx +$ $iy + jz$	$gw + gx$ $+ fy +$ $ky + lz$	$sw + hx$ $+ gy + lz$

additional parameter

padding $P = 0$



$P \geq 1$

original image $N \times N$ (I)
Filter $F \times F$ (W)

$$N = 7 \quad F = 3$$

$$\text{Stride} = 1 = S \quad P = 0$$

output size

$$(N - F) / S + 1$$

$$N = 7 \quad F = 3 \quad S = 1 \quad P = 0$$

+2P

output Dim 5×5

$$N = 7 \quad F = 3 \quad S = 2 \quad P = 0$$
$$\Rightarrow \text{Dim} = 3 \times 3$$

Example

input image $32 \times 32 \times 3$

10 outputs from convolution
 5×5 filters with stride = 1

$$P = 0$$

$$(32 - 5) / 1 + 1 \Rightarrow 28 \times 28 \times 3$$

10 images of dim $(28 \times 28) \times$
3 color
channels

Filter has $5 \times 5 \times 3 + 1 = 76$
parameters

Ten images 760 parameters

Typical sizes :

input $w_1 \times h_1 \times D_1$
width height depth

New hyperparameters

- K = number of filters
- F = spatial extent
- S = stride
- P = padding

produce our output

$$w_2 \times h_2 \times D_2$$

$$w_2 = (w_1 - F + 2P)/s + 1$$

$$h_2 = (h_1 - F + 2P)/s + 1$$

$$d_2 = k$$

we get then $F \times F \times d_1$ weights per filter and k -values which are all trained by back propagation.

k is often chosen in powers of 2

common settings

$$F = 3 \quad S = 1 \quad P = 1$$

$$F = 5 \quad S = 2 \quad P = 2$$

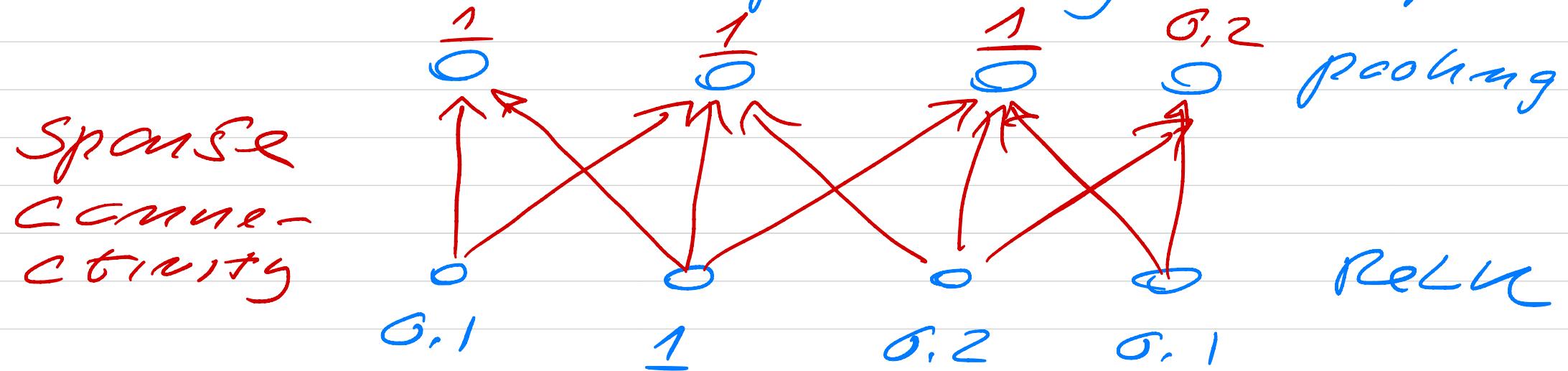
$$F = 5 \quad S = 2 \quad P = 0, 1, 2$$

Typical convolutional part

- one or several convolutions in parallel in order to produce several (or one) copies (reduced) of the original input
- ReLU (linear activation)

- pooling stage

- max pooling example



"no parameters" in pooling stage

"no parameters" in ReLU

"no parameters" means do not enter training stage