FYS-STK3155/4155 lecture, October 28, 2024

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$$y(i) = \sum_{k=0}^{k=m-1} \underbrace{x(i-k)}_{\text{input}} \underbrace{w(k)}_{\text{weight/filter}}$$

$m = 3$

$$y(0) = x(0)w(0) + x(-1)w(1) + x(-2)w(2)$$

Original β_0 β_1 β_2 β_3

$x(0)$ $x(1)$ $x(2)$ $x(3)$ 3rd order

$w(0)$ $w(1)$ $w(2)$ 2nd order

α_0 α_1 α_2

$$y(1) = x(0)\,w(0) + w(1)\,x(0) + x(-1)\,w(2)$$

$$\vdots$$

$$y(5) = x(5)\,w(0) + x(4)\,w(1) + w(2)\,x(5)$$

$x(-2)$ | $x(-1)$ | $x(0)$ | $x(1)$ | $x(2)$ | $x(3)$ | $x(4)$ | $x(5)$

padding

parameter p

a "padded" vector with

size $n + 2p = 4 + 4 = 8$

n ↑ original size

relabel/reorder

$x(0) = x(-2)$ $x(1) = x(-1)$

$x(2) = x(0)$ . .

$$y(i) = \sum_{k=0}^{k=m-1} x(i+(m-1-k))\, w(k)$$

$y(0) = x(2)\, w(0)$ $\{\alpha_0 \beta_0\}$

$$y(1) = x(4)\,w(0) + x(3)\,w(1) + x(2)\,w(2)$$

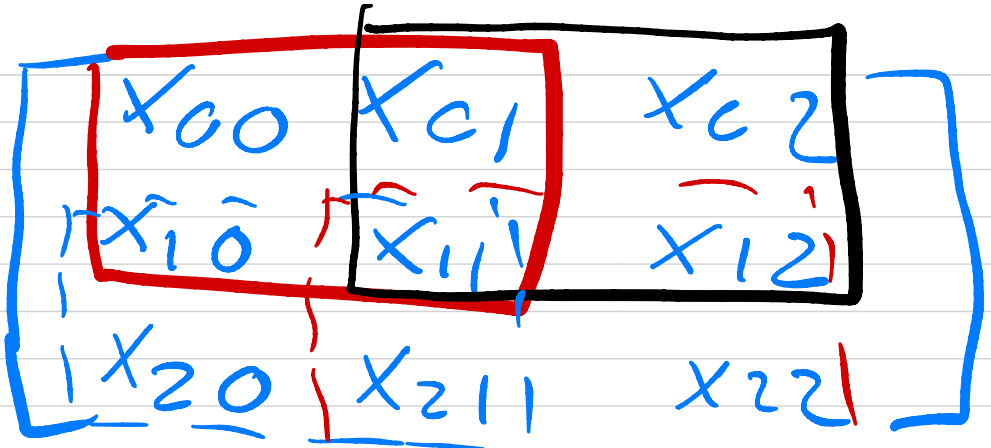
if we redefine

$$\tilde{w}(2) = w(0) \qquad \tilde{w}(1) = w(1)$$

$$\tilde{w}(0) = w(2)$$

can then rewrite the whole operation as

$$x(i : i+m)\,\tilde{w}$$



3×3

$*$

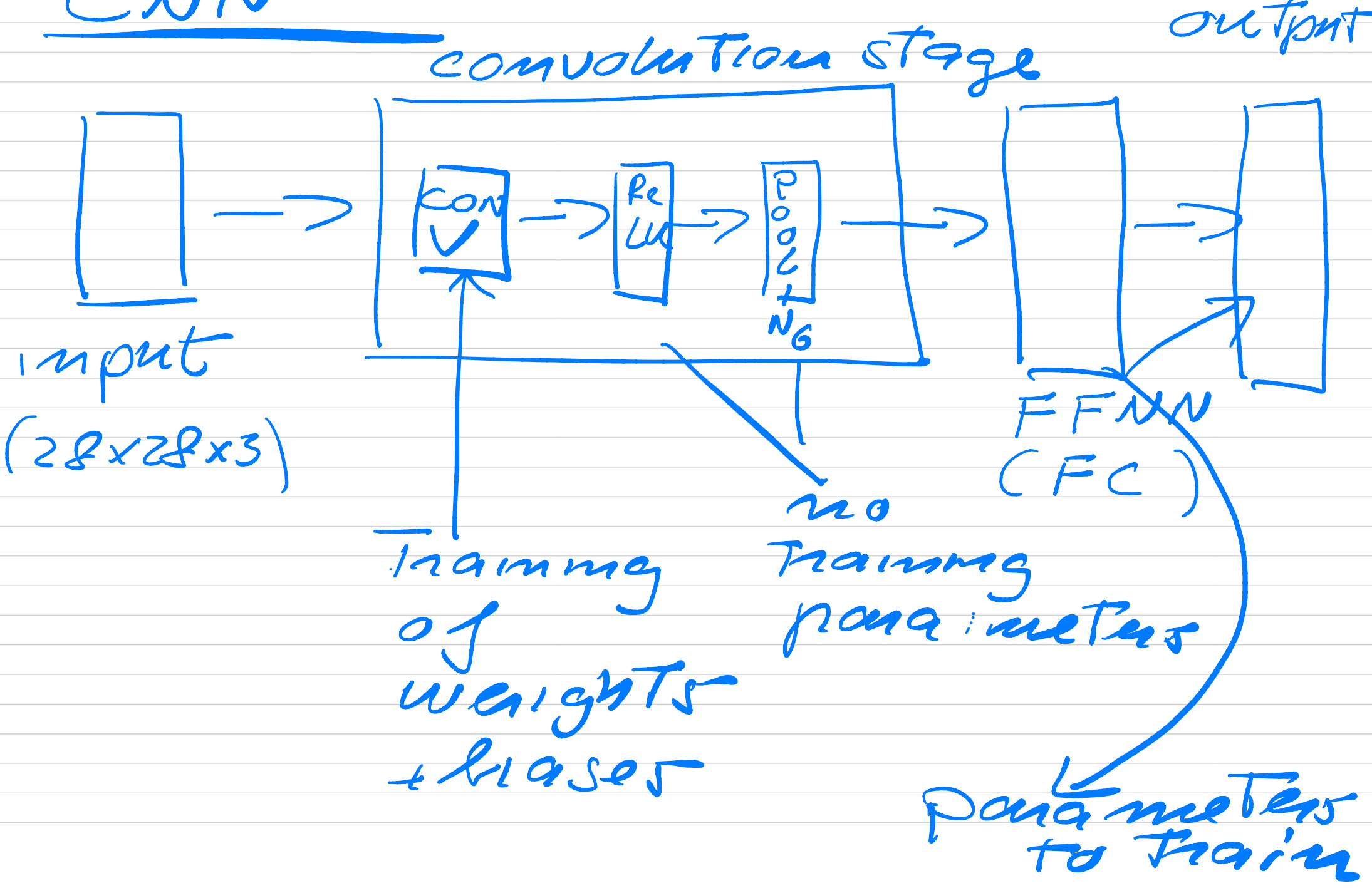
$$\begin{bmatrix} w_{00} & w_{01} \\ w_{10} & w_{11} \end{bmatrix}$$

2×2

$$= \begin{bmatrix} x_{00}w_{00} + x_{01}w_{01} \\ + x_{10}w_{01} + x_{11}w_{11} & \cdots \\ \cdots & \cdots \end{bmatrix}$$

stride $S = 1$

CNN


convolution stage
output
Conv
ReLU
POOL + NG
input
(28x28x3)
FFNN
(FC)
training of weights + biases
no training parameters
parameters to train

Example:

$32 \times 32 \times 3$

10 Filters a 5×5 with Stride = 1

Padding

$P = 0$

no padding produces then

$W_2 \quad H_2 = (32)$

$W \times H \times D$

width height \ Depth

New parameters (hyperparams)

- K number of filters
- spatial extent W = H = F
- The stride S
- amount of zero padding P

Reduction of the original data W_1 H_1

$$W_2 = (W_1 - F + 2P)/S + 1$$

$$H_2 = (H_1 - F + 2P)/S + 1$$

D_2 = k number of filters

original $32 \times 32 \times 3$

10 Filters a 5×5 (F x F)

$$W_2 = (32 - 5)/1 + 1 = 28$$

$\Rightarrow$ 28×28

include color channels

per filter $5 \times 5 \times 3 + 1$

Bias

$= 76$ parameters

10 filters $\Rightarrow$

760 parameters

common settings

$F = 3$ $S = 1$ $P = 1$

$F = 5$ $S = 1$ $P = 2$

$F = 5$ $S = 2$ $P = ?$

whatever fits best