

Agenda

- Recap
- ANN Code
- CNN
 - × Why CNN?
 - × Visual Cortex
 - × Convolution layer: filter
 - × Pooling layer
 - × Flatten & fully connected layer
 - × Padding & stride

Convolutional layer

image

filter/Kernel

filtered image

1	3	2	3	2	2
2	0	1	3	0	1
1	0	2	0	0	3
1	3	1	1	3	0
2	1	0	0	2	0
1	1	2	3	3	1

6×6

1	2	1
1	0	1
1	2	0

3×3

-1		

$$1 + 6 + 2 + 2 + 0 + 1 + 1 + 0 + 0 = -1$$

1	3	2	3	2	2
2	0	1	3	0	1
1	0	2	0	0	3
1	3	1	1	3	0
2	1	0	0	2	0
1	1	2	3	3	1

6×6

*

1	2	1
1	0	1
1	2	0

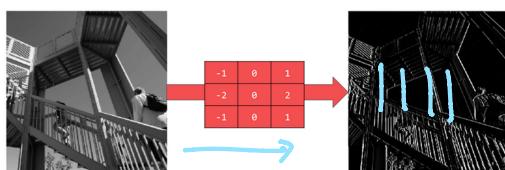
3×3

-1	5	4	1
2	1	2	3
1	1	0	1
2	3	2	1

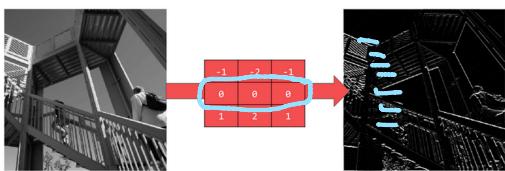
4×4
16

5×5

Using $[-1, 0, 1, -2, 0, 2, -1, 0, 1]$ gives us a very strong set of vertical lines:



Using $[-1, -2, -1, 0, 0, 0, 1, 2, 1]$ gives us horizontal lines:



Colored my
grays. ing
PNA

Source:

tensorflow.com

$28 \times 28 \rightarrow 784$

$784 \times 3 \rightarrow 2200$

filtered img

filtered my

0	5	4	1
2	1	2	3
1	1	0	1
2	3	2	1

Relu 

0	5	4	1
2	1	2	3
1	1	0	1
2	3	2	1

4×4

Pooling Layer

More pooling (2,2)

$$36 \Rightarrow 16 \Rightarrow 4$$

filtered
in my

$$\begin{array}{|c|c|c|c|} \hline
 0 & \cancel{5} & \cancel{4} & 1 \\ \hline
 2 & 1 & 2 & 3 \\ \hline
 1 & 1 & 0 & 1 \\ \hline
 2 & 3 & \cancel{2} & 1 \\ \hline
 \end{array} \longrightarrow \begin{array}{|c|c|} \hline
 5 & 4 \\ \hline
 3 & 2 \\ \hline
 \end{array} \quad \underline{2 \times 2 = 4}$$

Average pooling (2, 2)

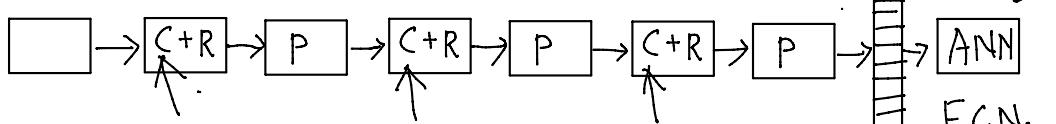
1	5	4	1
2	1	2	3
1	1	0	1
2	3	2	1

Complete CNN

i/p img 1st

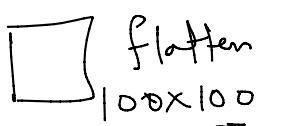
2nd

3-1



→ No-

CNN with optional pooling layers



F. L.

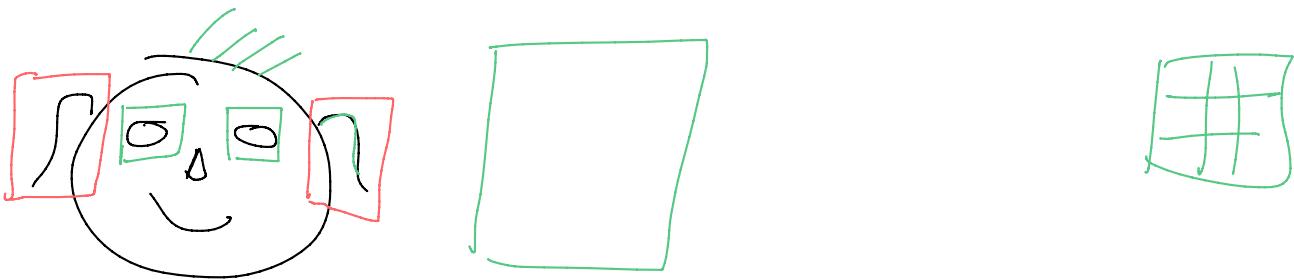
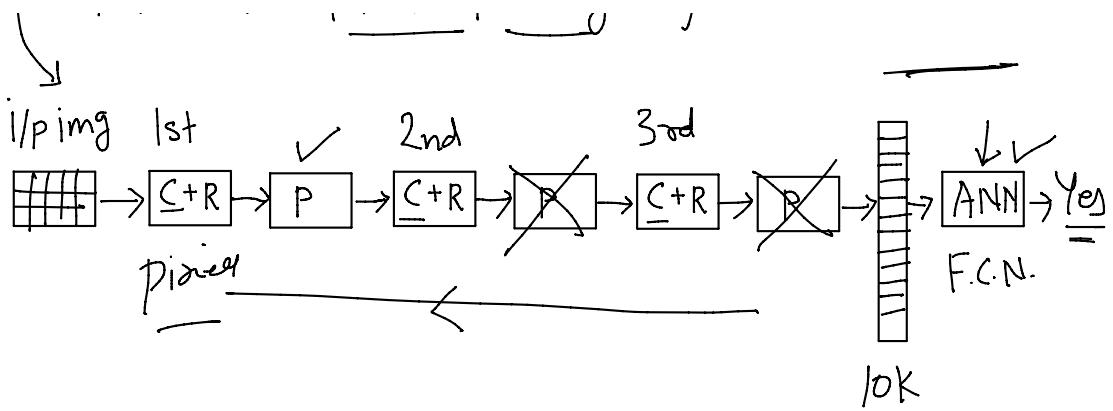
11

F.C.N.

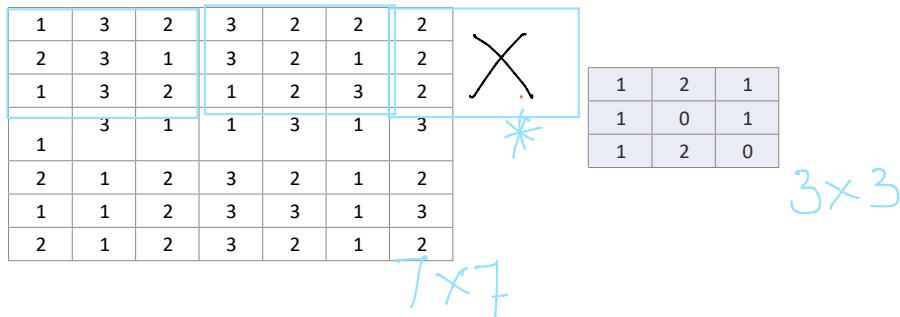
F.C.N.

F.C.N.

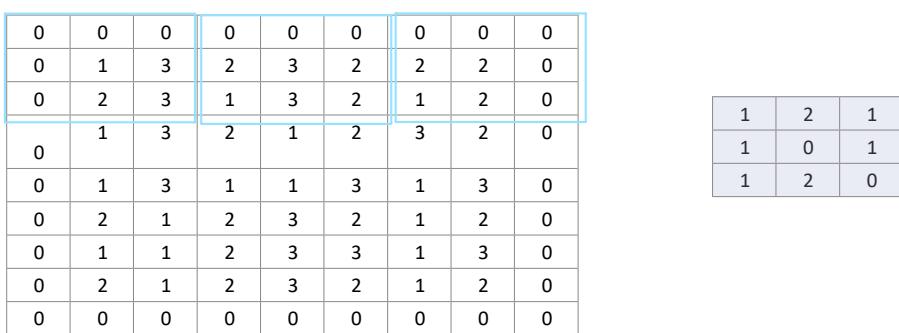
10K



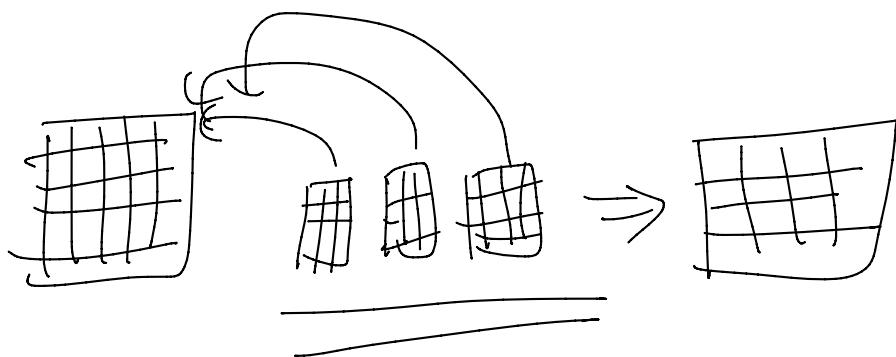
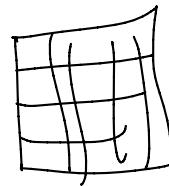
stride = 3



stride = 3, padding = 1 or (1,1) or 1x1



$\checkmark n$ -estimator



C_1 C_2 $C_3 \dots$

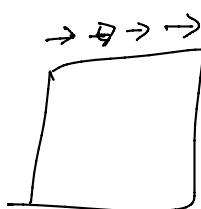
32

64

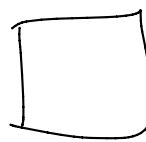
64 128

2-bin

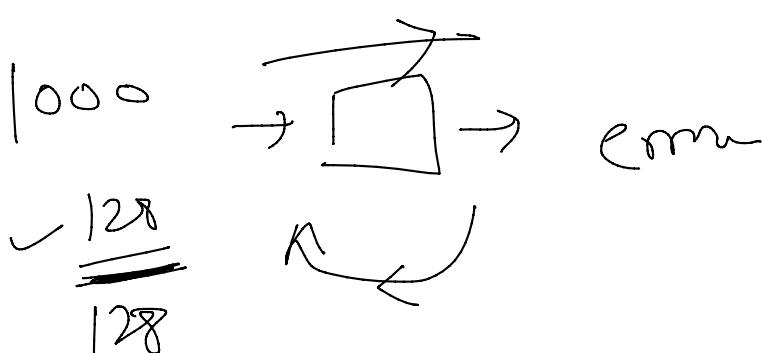
1



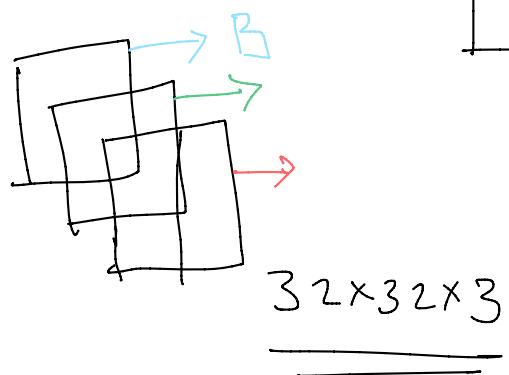
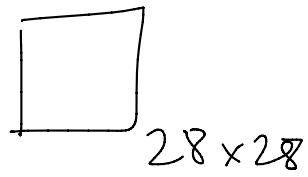
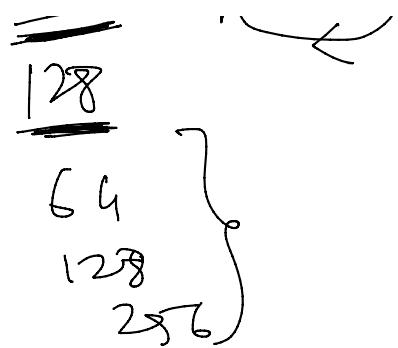
28×28



3×3



32
64
128



32x32x3



VRNN \rightarrow text