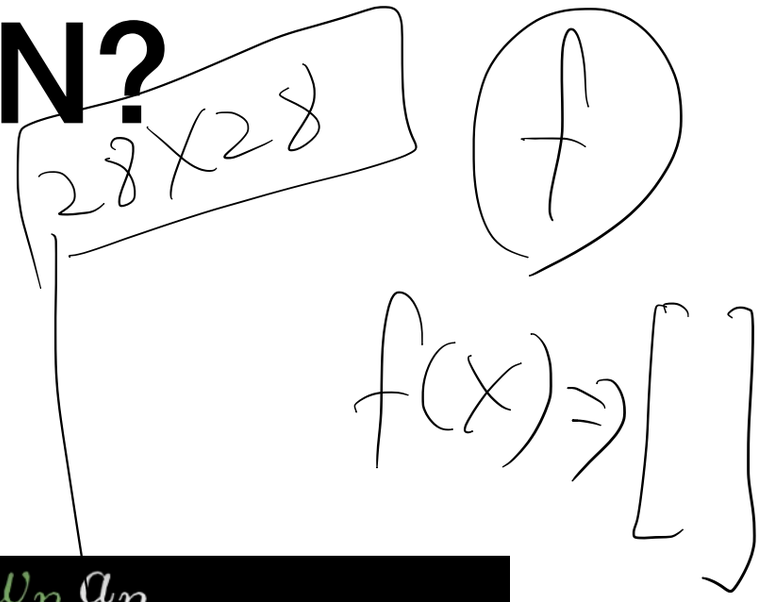
Convolutional Neural Net.

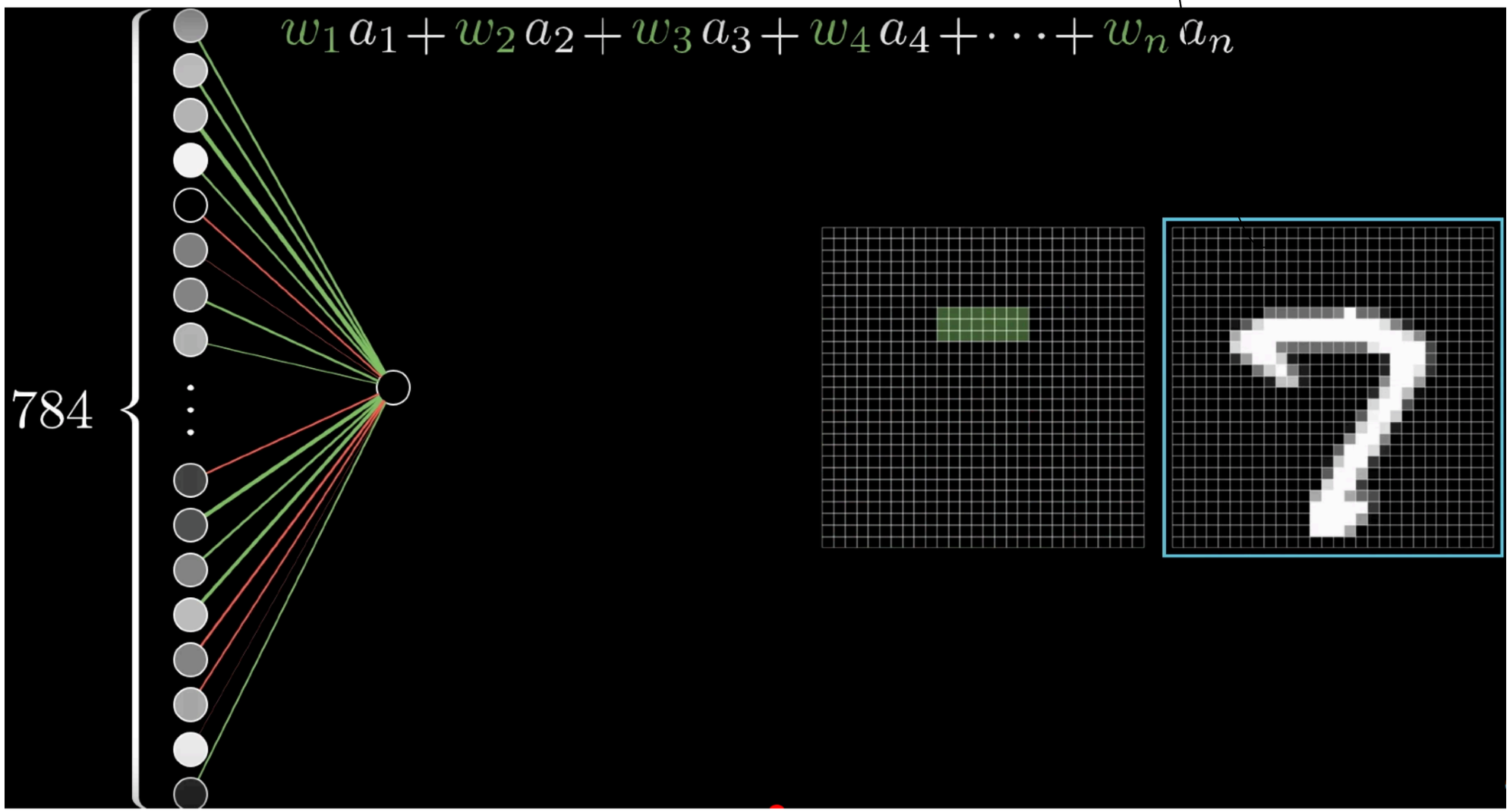
Seyoung Yun

- http://cs231n.stanford.edu/slides/2017/cs231n_2017_lecture5.pdf
- http://www.di.ens.fr/~lelarge/dldiy/slides/lecture_6/index.html#80

Why we need CNN?

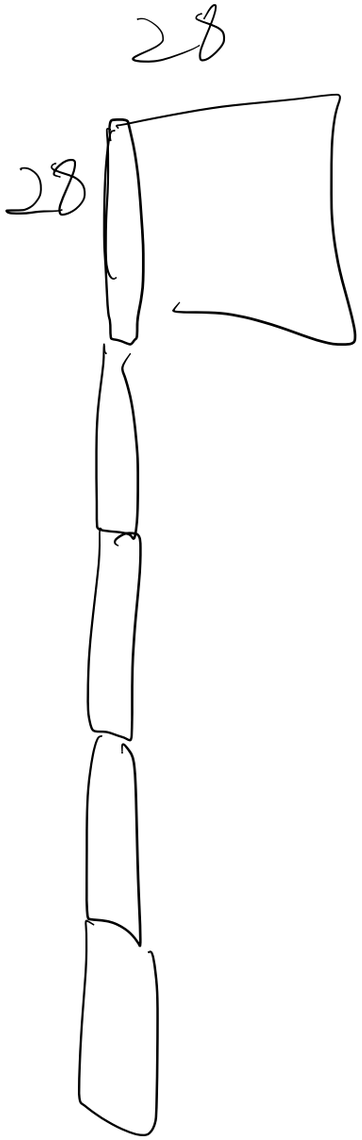


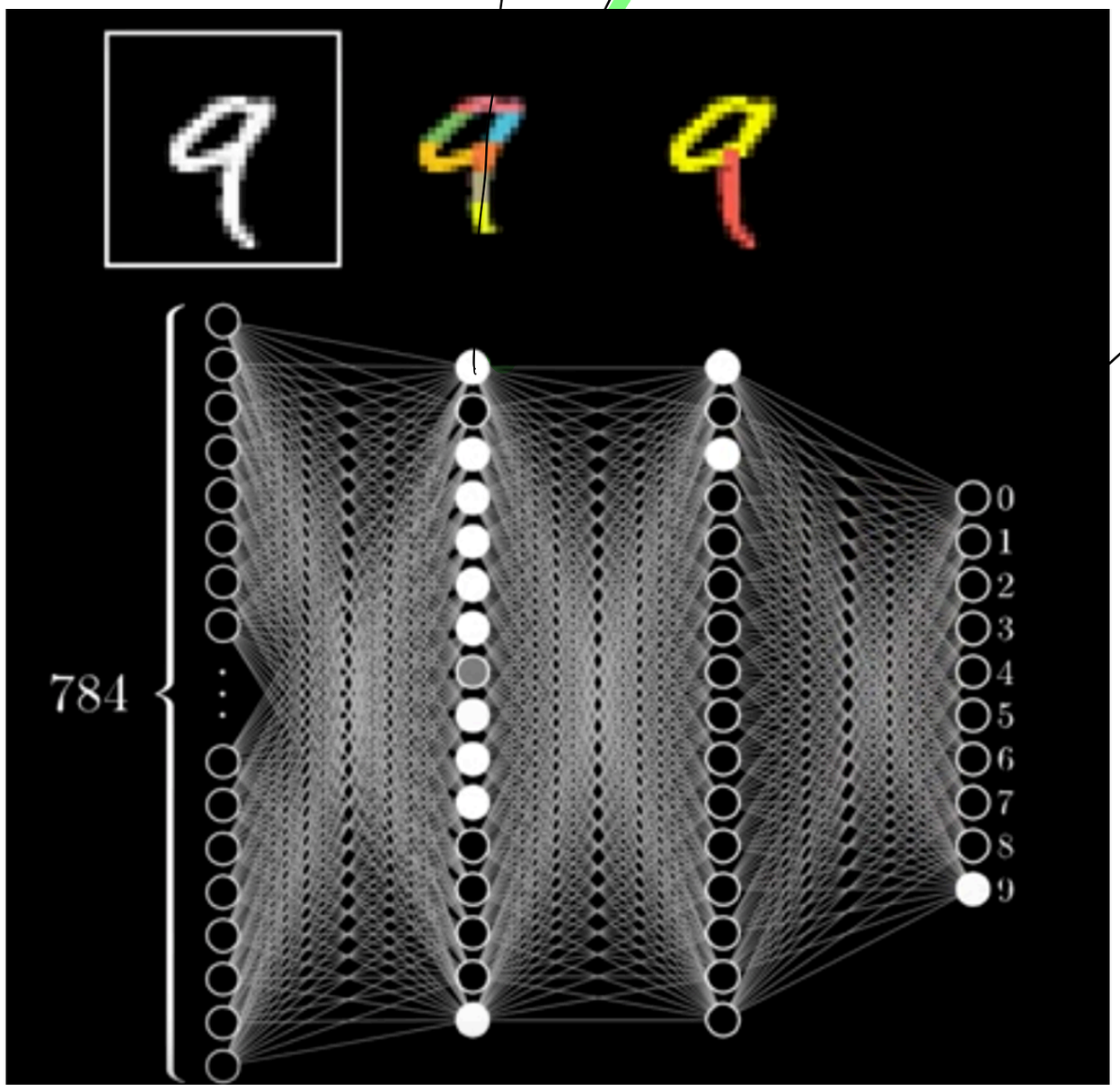
- With a single neuron?

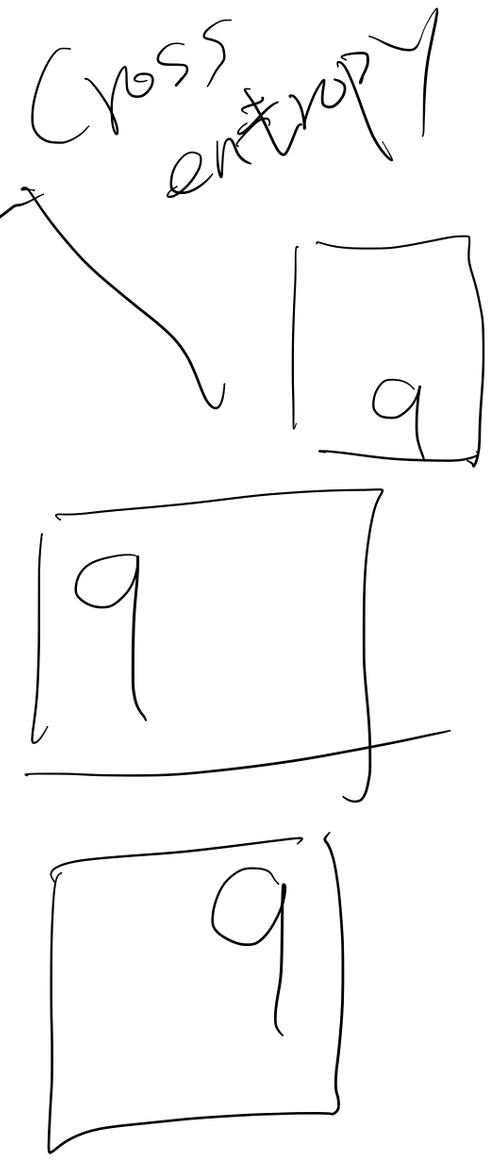


Why we need CNN?

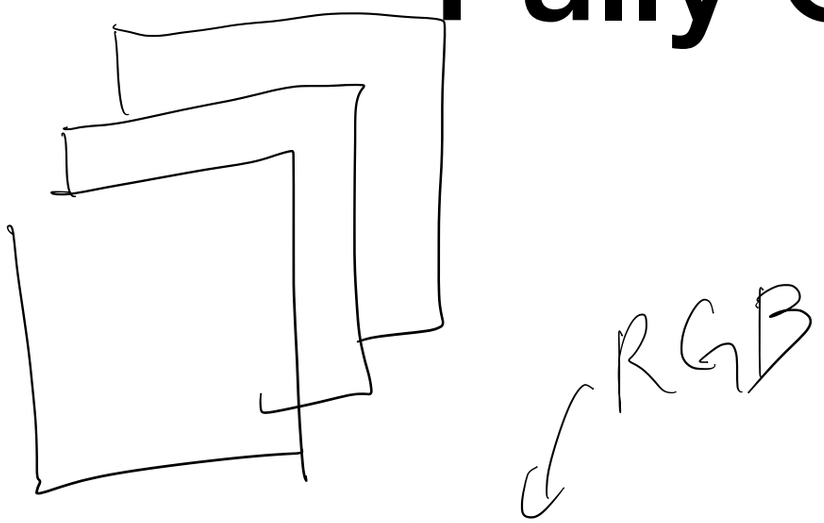
- With FNN?



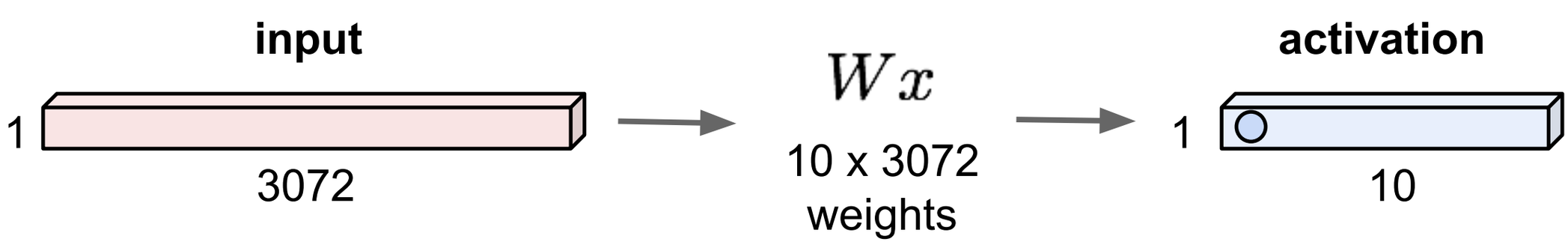




Fully Connected Layer

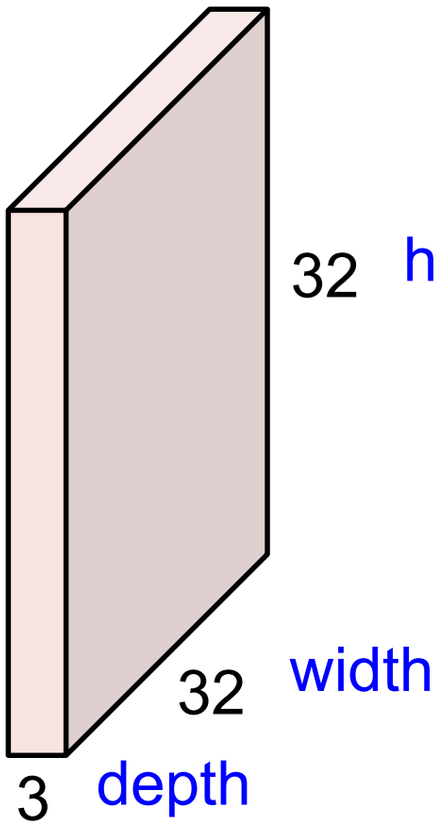


32x32x3 image -> stretch to 3072 x 1

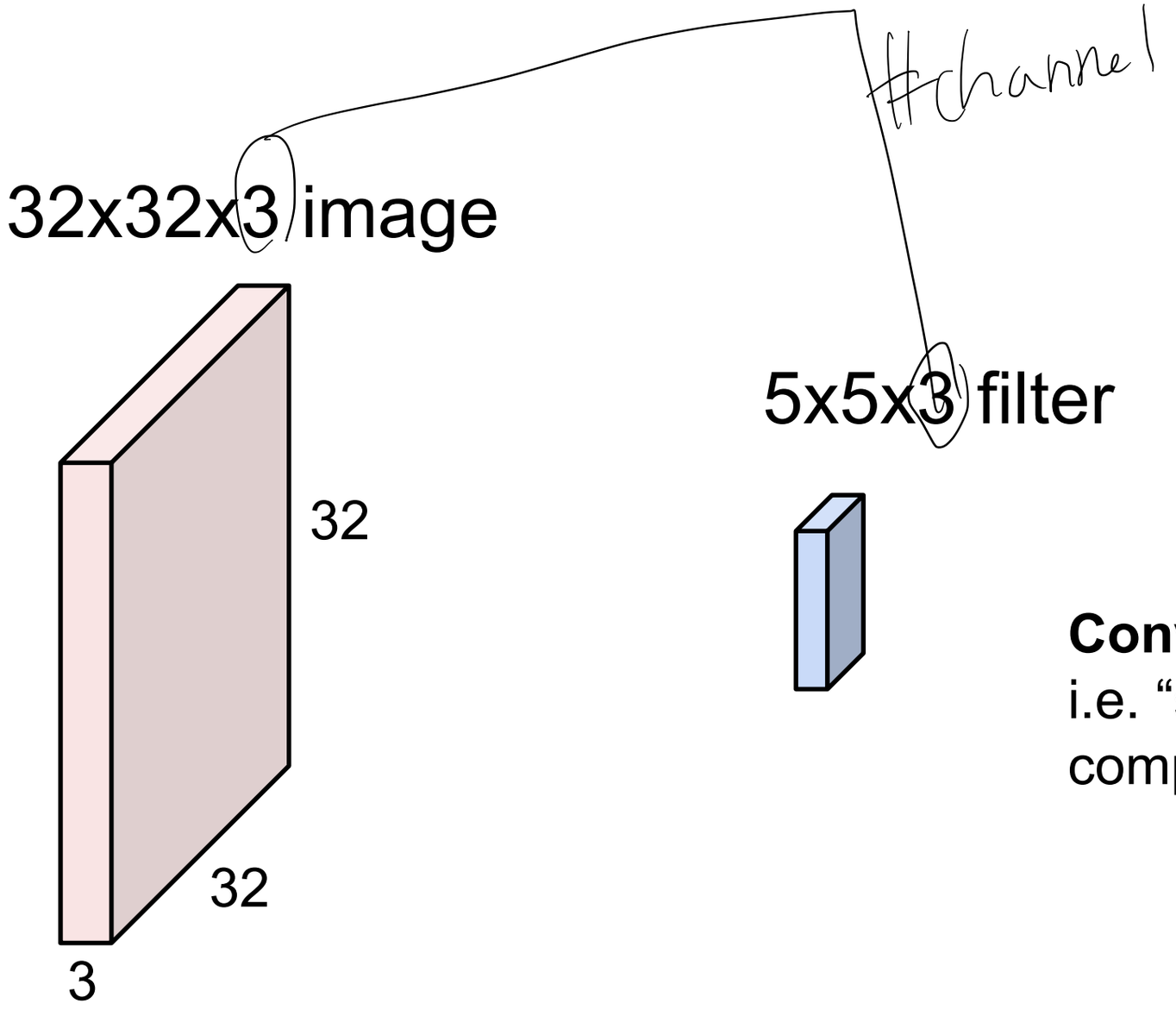


Convolution Layer

32x32x3 image -> preserve spatial structure

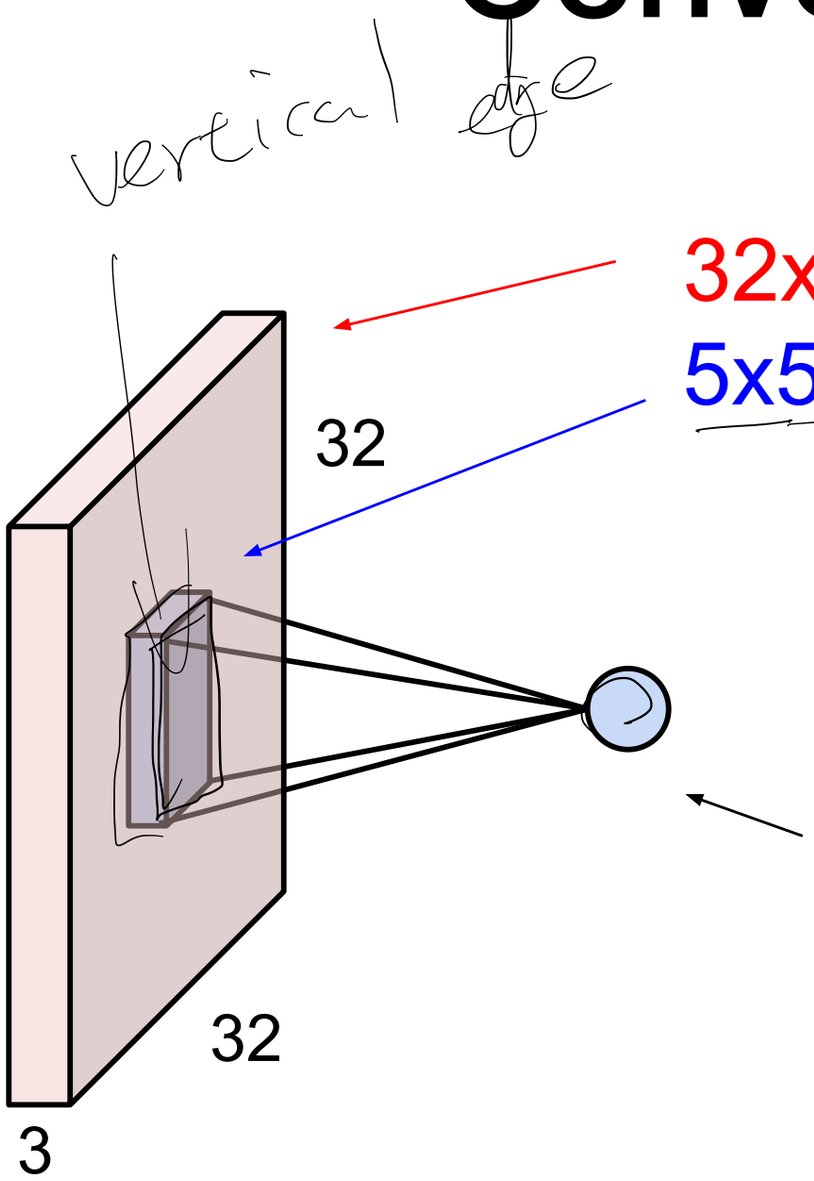


Convolution Layer



Convolve the filter with the image
i.e. “slide over the image spatially, computing dot products”

Convolution Layer



32x32x3 image

5x5x3 filter w

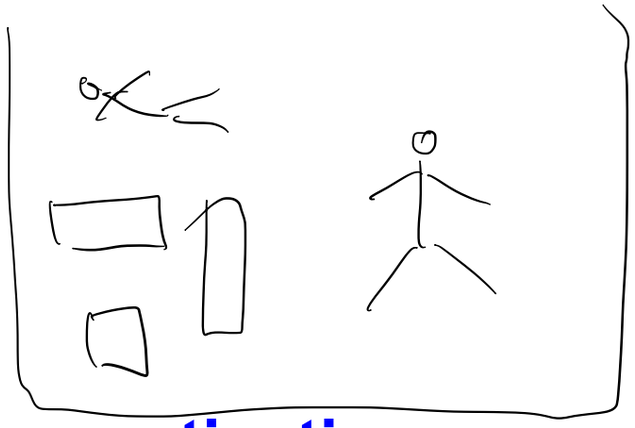
1 number:

the result of taking a dot product between the filter and a small 5x5x3 chunk of the image (i.e. 5*5*3 = 75-dimensional dot product + bias)

$$w^T x + b$$

(32x32x3) x (28x28) = ?

Convolution Layer



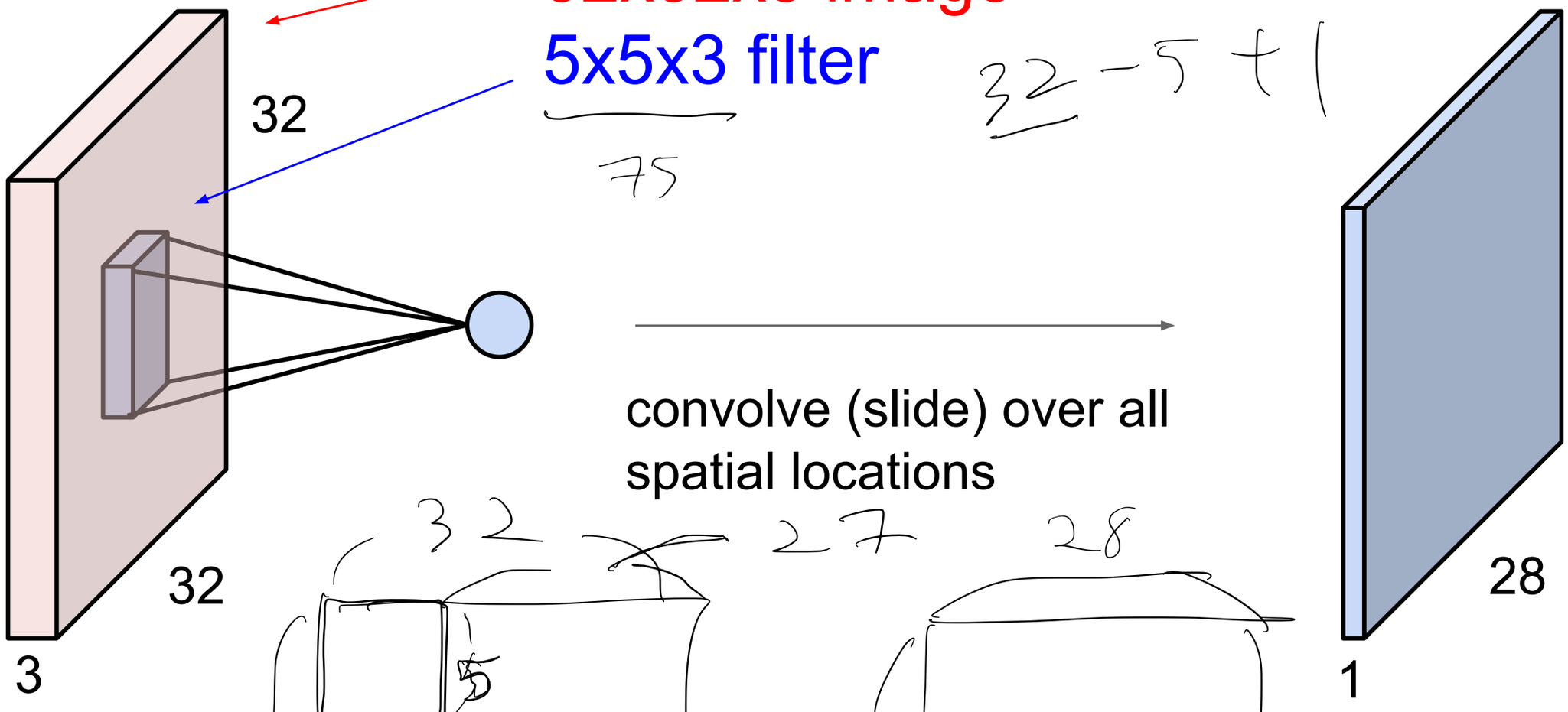
activation map

32x32x3 image

5x5x3 filter

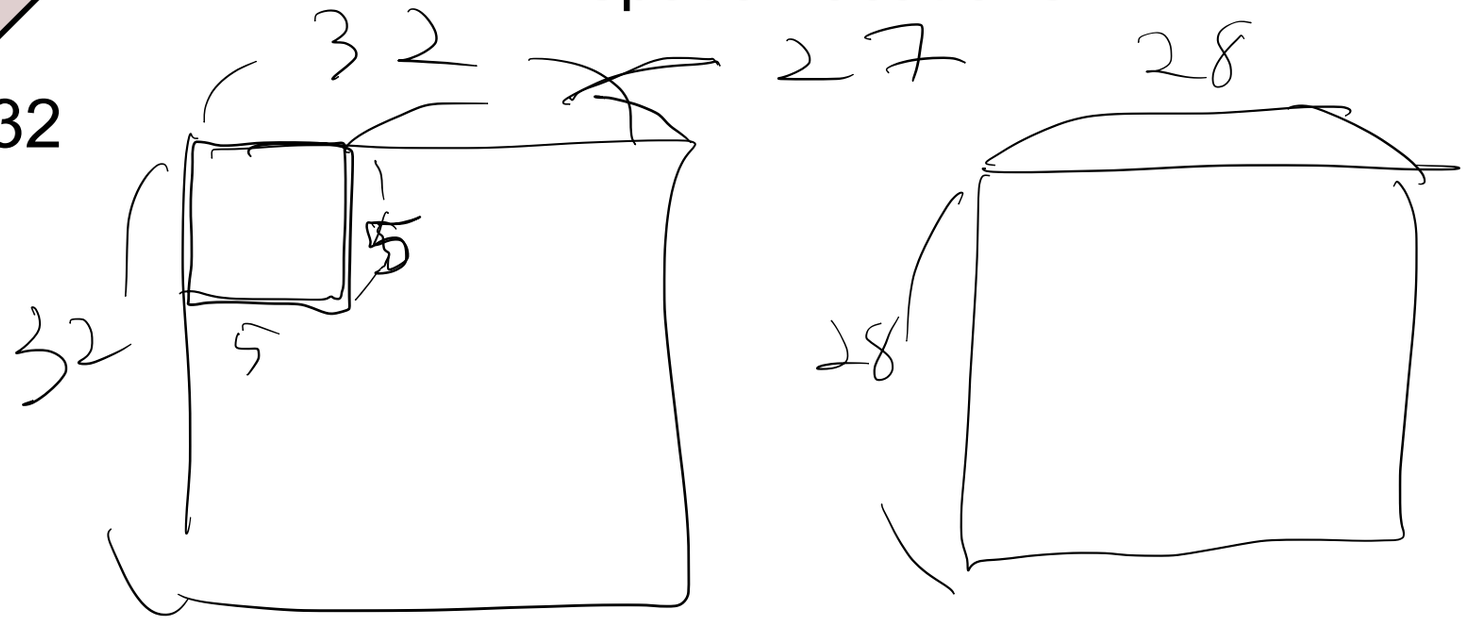
75

32 - 5 + 1

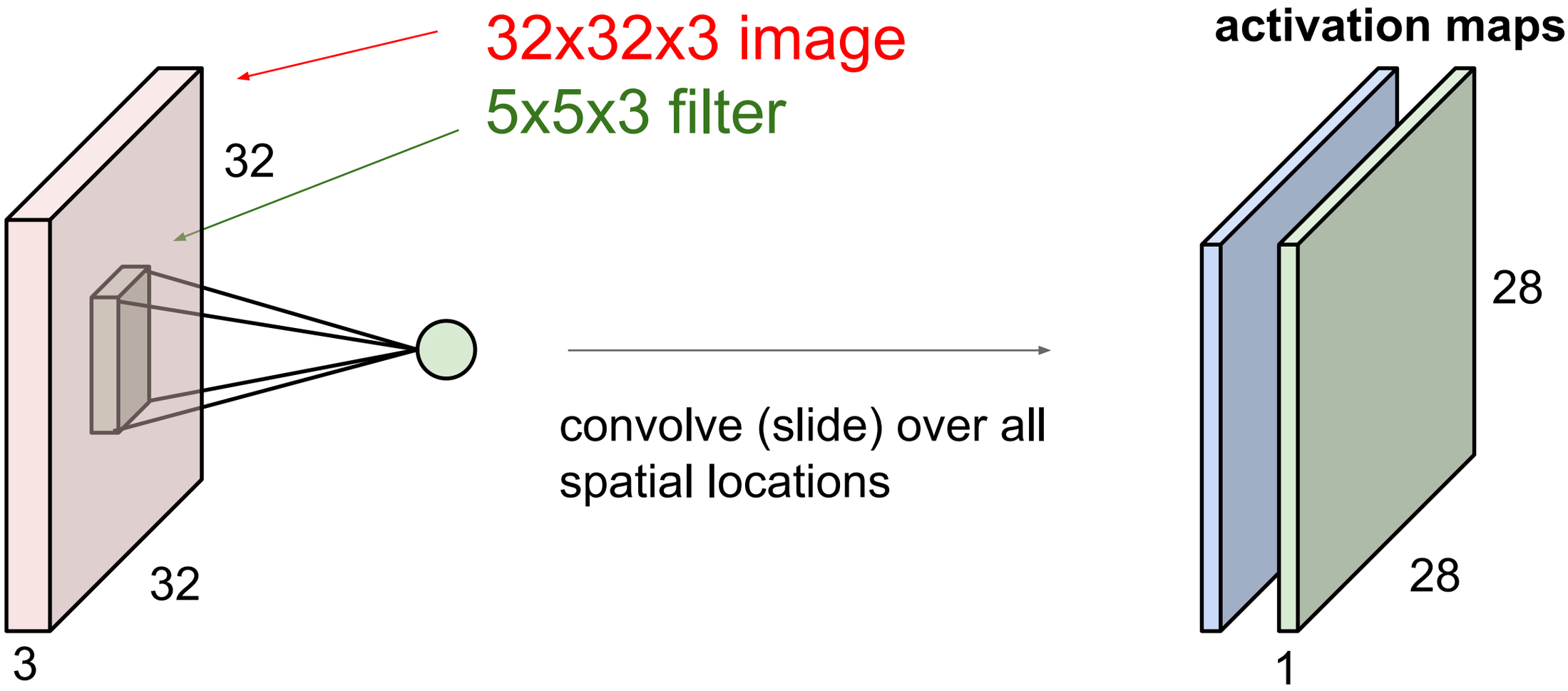


convolve (slide) over all spatial locations

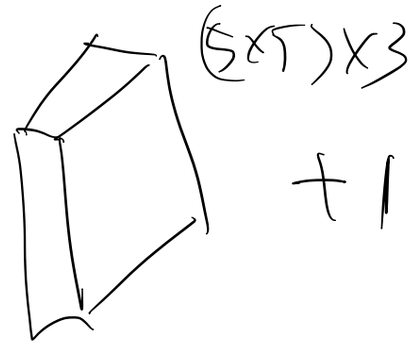
32 27 28



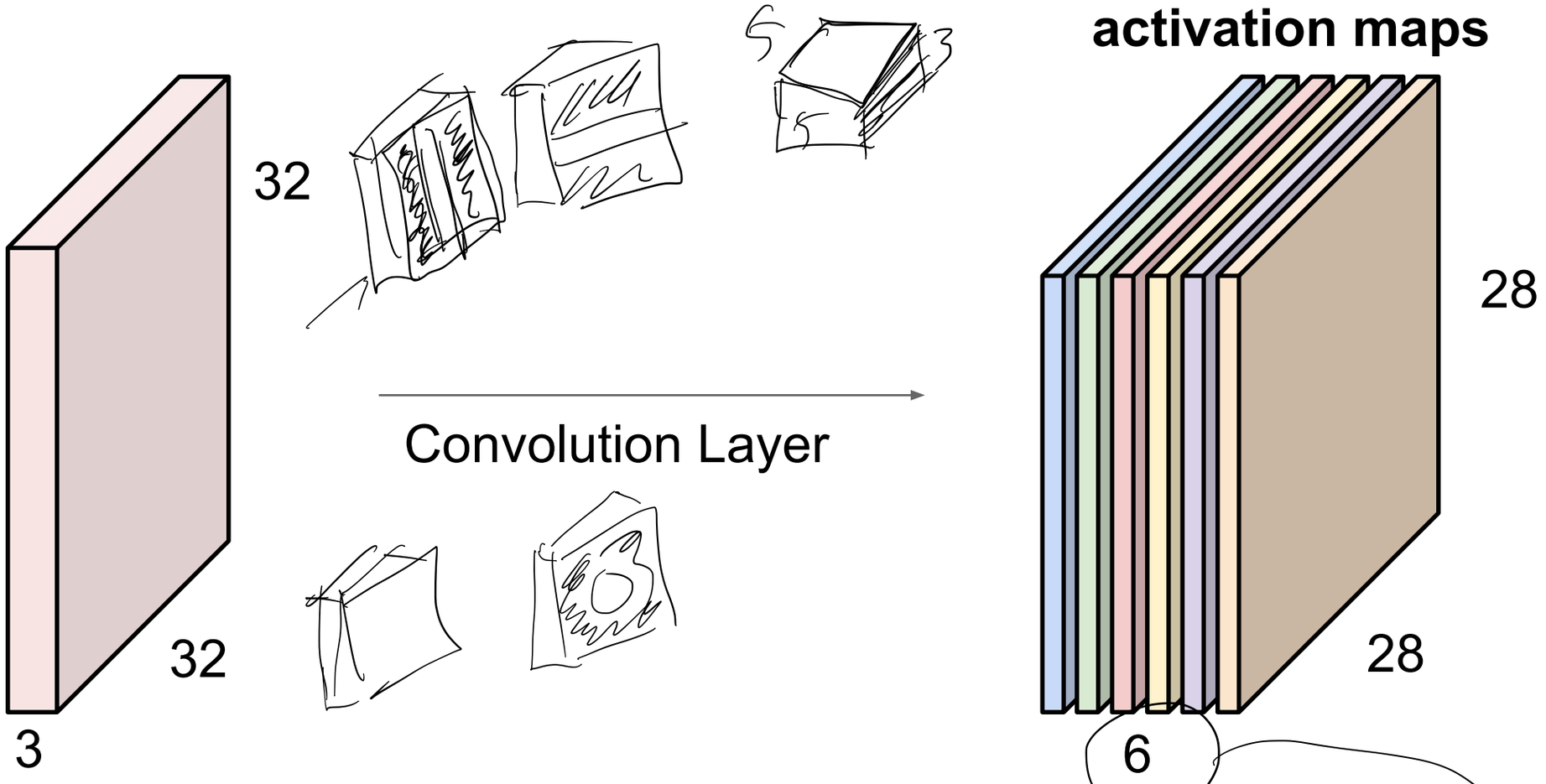
Convolution Layer



Convolution Layer



For example, if we had 6 5x5 filters, we'll get 6 separate activation maps:



We stack these up to get a "new image" of size 28x28x6!

What is Convolution?

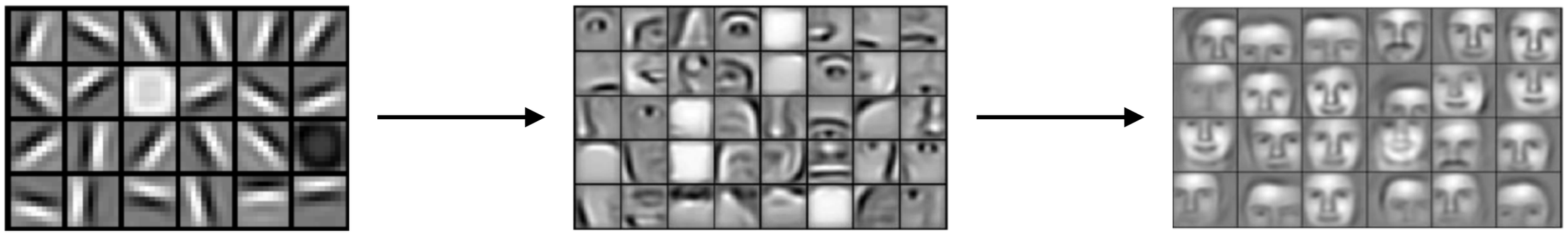
- Convolution

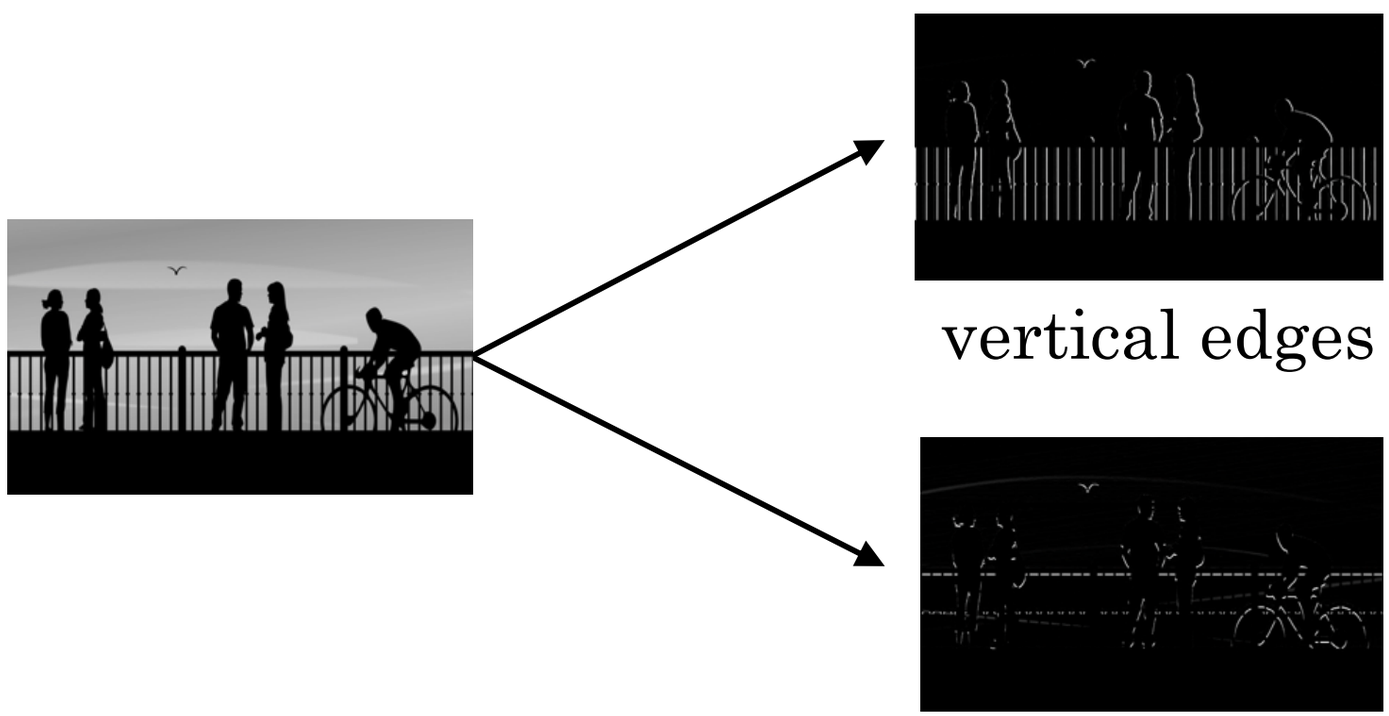
$$S(i,j) = (I * K)(i,j) = \sum_m \sum_n I(m,n)K(i-m, j-n).$$

- Cross-correlation

$$S(i,j) = (I * K)(i,j) = \sum_m \sum_n I(i+m, j+n)K(m,n).$$

Edge Detection





Edge Detection

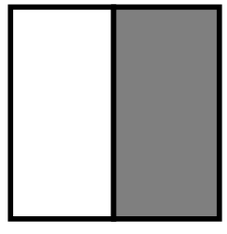
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0

*

1	0	-1
1	0	-1
1	0	-1

=

0	30	30	0
0	30	30	0
0	30	30	0
0	30	30	0



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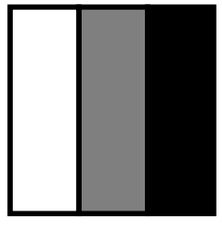
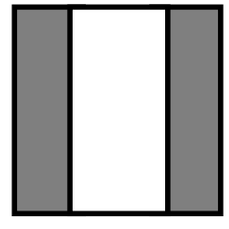




Edge Detection

1	0	-1
1	0	-1
1	0	-1

Vertical

1	1	1
0	0	0
-1	-1	-1

Horizontal

10	10	10	0	0	0
10	10	10	0	0	0
10	10	10	0	0	0
0	0	0	10	10	10
0	0	0	10	10	10
0	0	0	10	10	10

*

1	1	1
0	0	0
-1	-1	-1

=

0	0	0	0
30	10	-10	-30
30	10	-10	-30
0	0	0	0

Padding

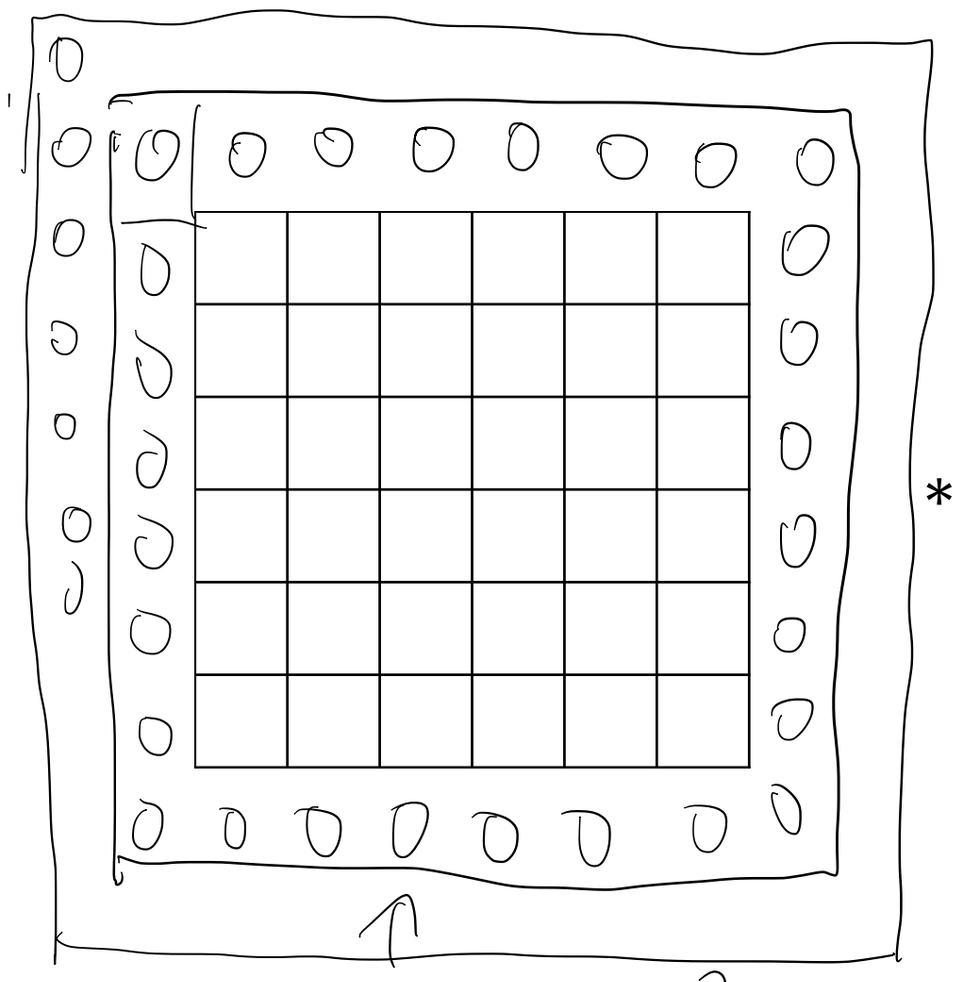
d x d

p

padding size

f

filter size.



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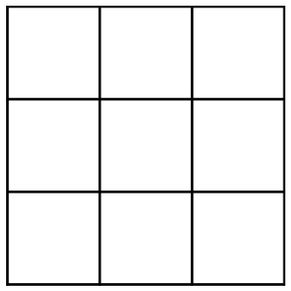

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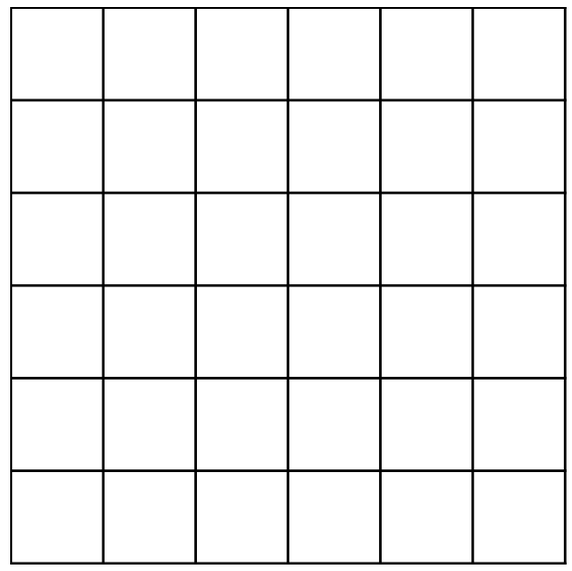
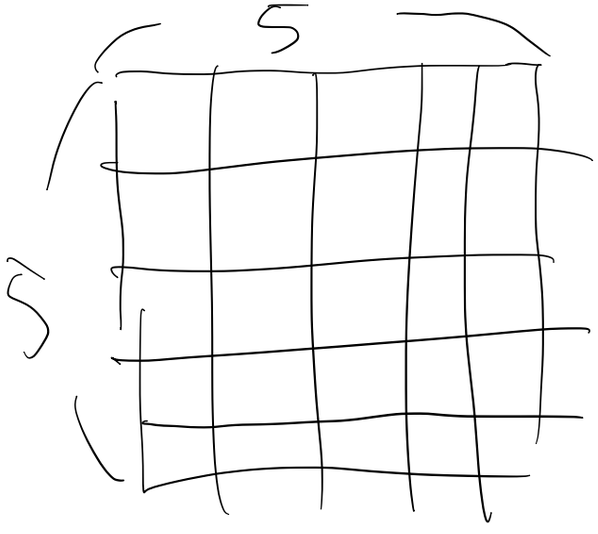
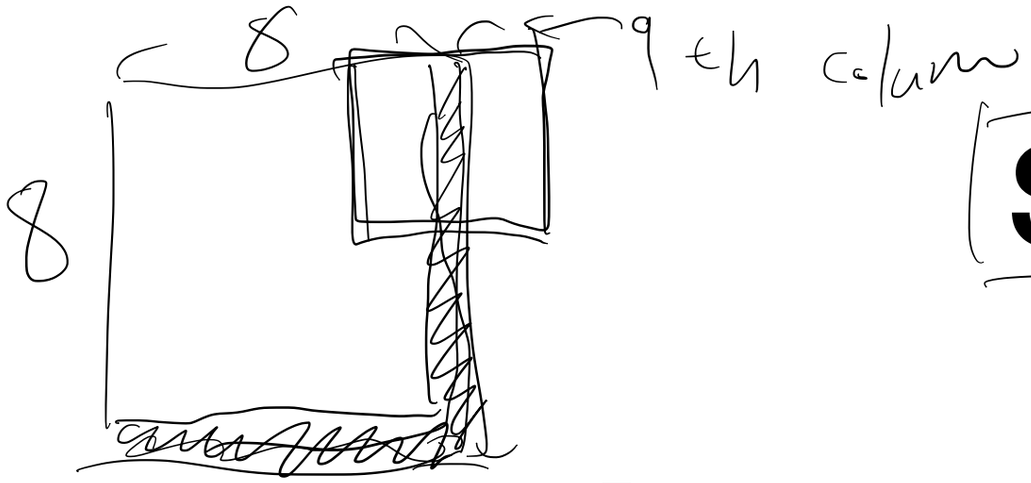


6X6 → 8X8



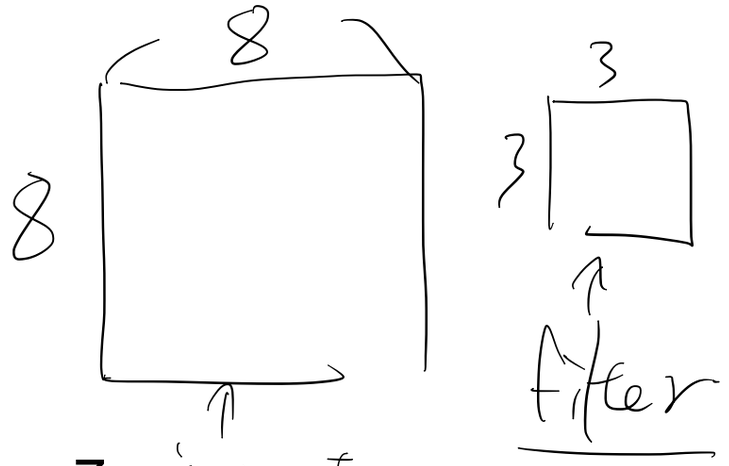
(d+2p) - f + 1

→ 10 X 10

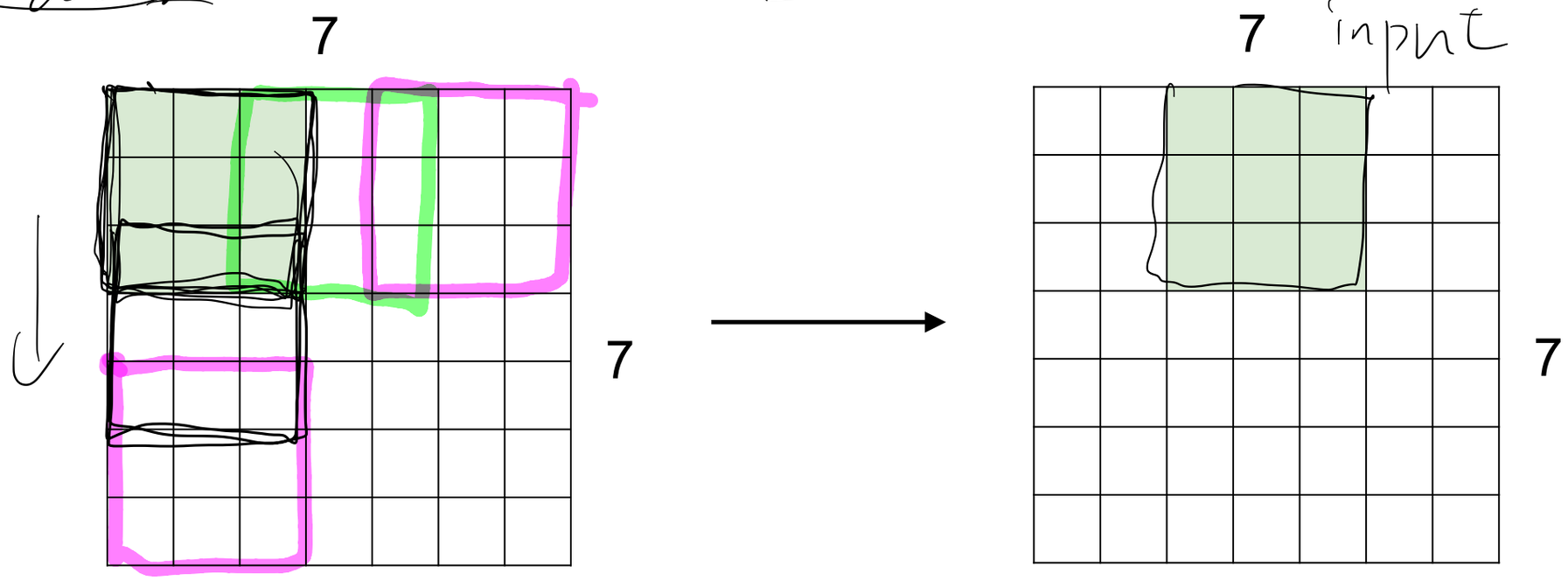


Stride

$S = 2$



$S = 2$



$\Rightarrow$ $3 \mid \# \in \left\lfloor \frac{(d + 2 \cdot p) - f}{S} \right\rfloor + 1$

Example

input : 100 x 100

filter : 7 x 7

padding : 1

stride : 2.

output ? $\left\lfloor \frac{100+2-7}{2} \right\rfloor + 1$

$\frac{95}{}$

47 + 1

Types of layer in a convolutional network

- Convolution
- Pooling
- Fully connected

Max pooling

Avg pooling

f = 2 x 2.

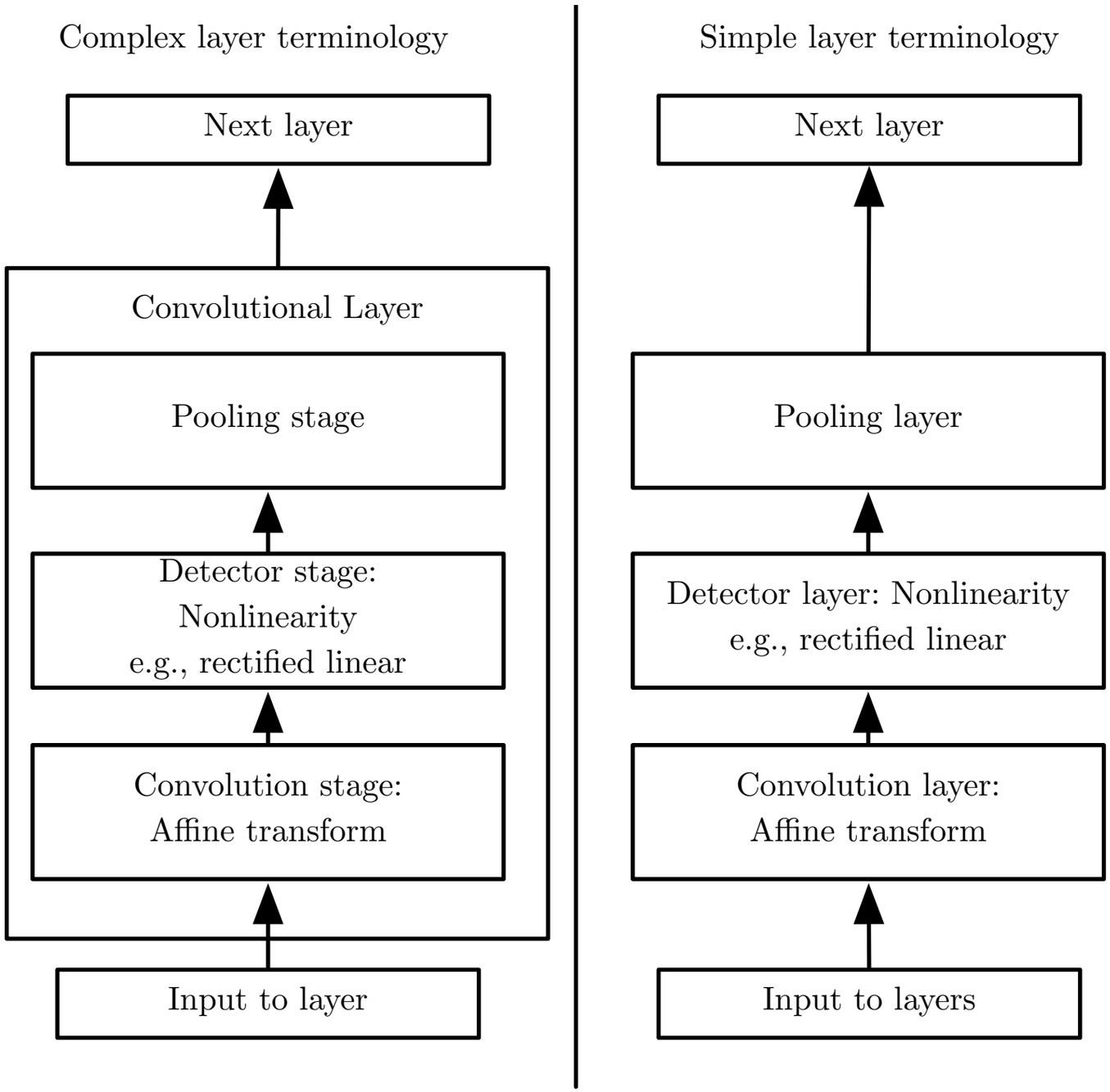
S = 2

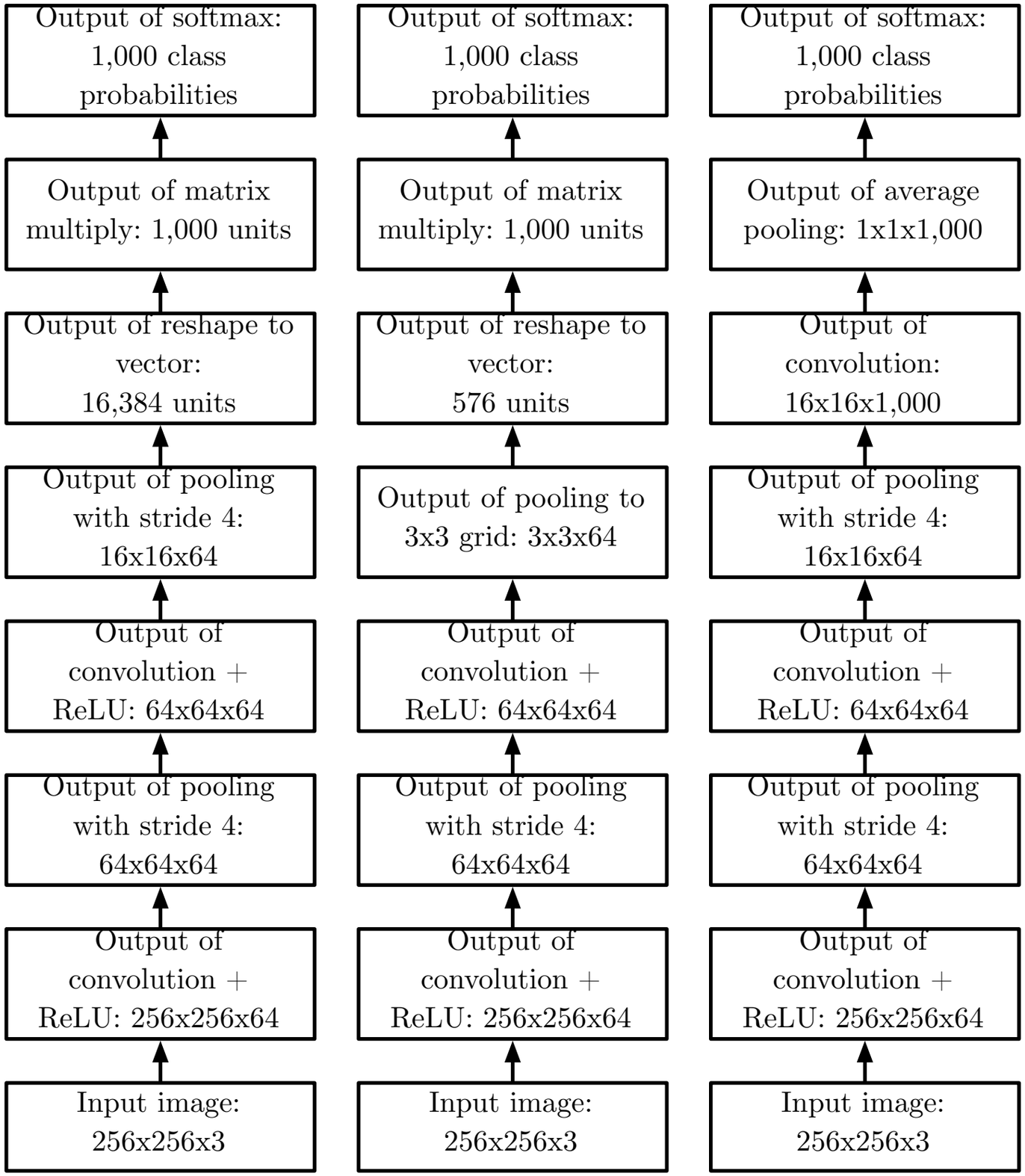
1	3	2	1
2	9	1	1
1	3	2	3
5	6	1	2

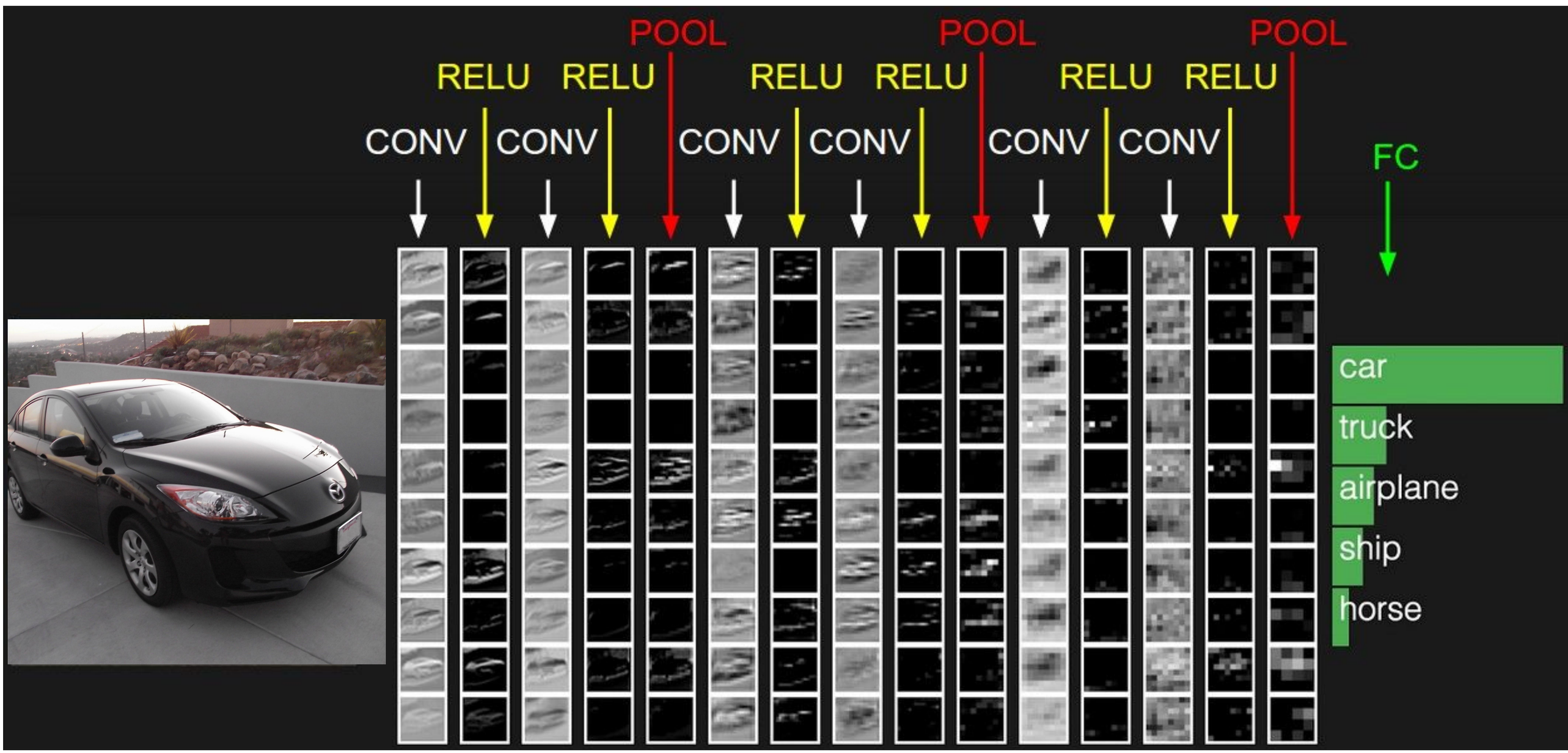
9	2
6	3

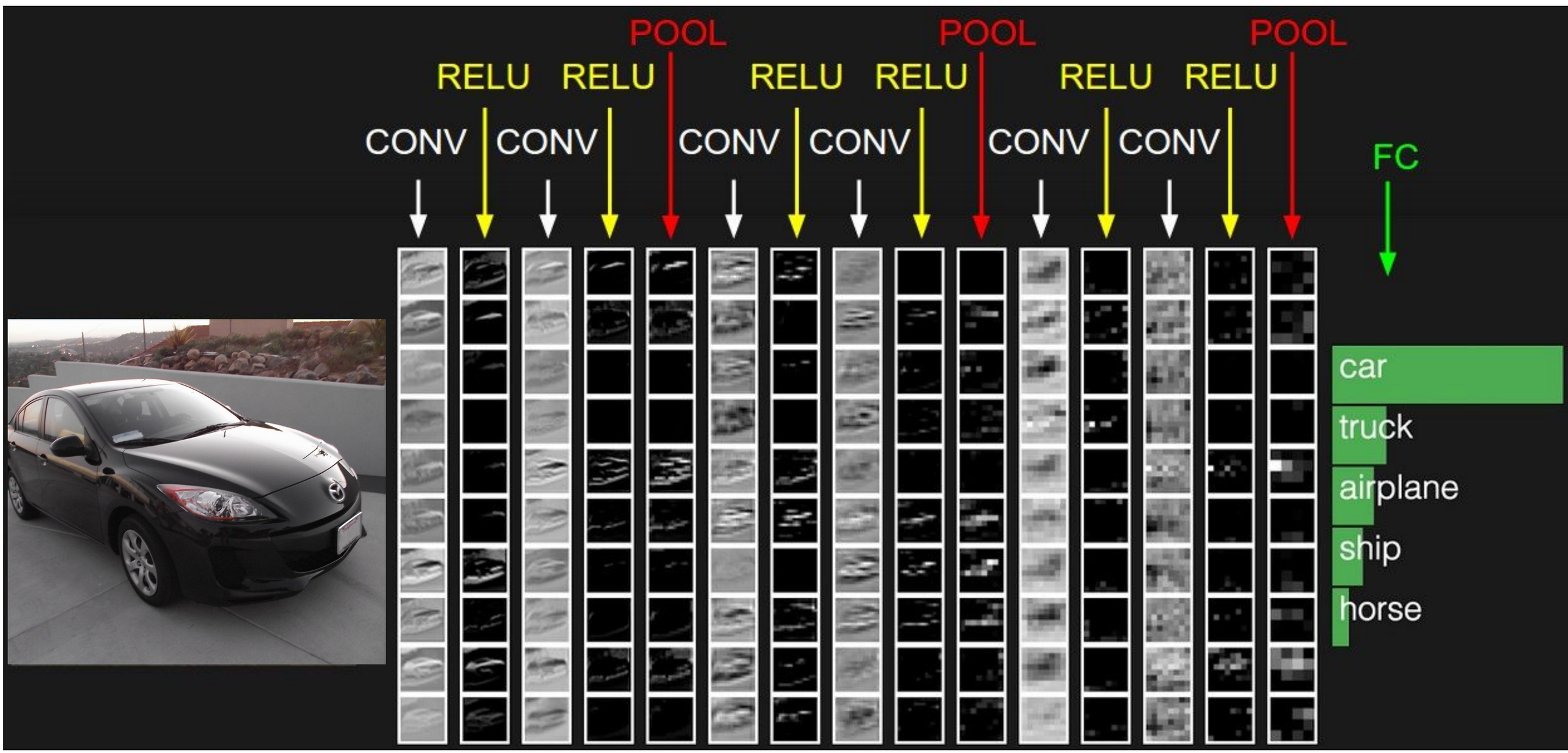
(d − f + 1)

CNN


Complex layer terminology
Next layer
Convolutional Layer
Pooling stage
Detector stage:
Nonlinearity
e.g., rectified linear
Convolution stage:
Affine transform
Input to layer
Simple layer terminology
Next layer
Pooling layer
Detector layer: Nonlinearity
e.g., rectified linear
Convolution layer:
Affine transform
Input to layers


Output of softmax: 1,000 class probabilities
Output of matrix multiply: 1,000 units
Output of reshape to vector: 16,384 units
Output of pooling with stride 4: 16x16x64
Output of convolution + ReLU: 64x64x64
Output of pooling with stride 4: 64x64x64
Output of convolution + ReLU: 256x256x64
Input image: 256x256x3
Output of softmax: 1,000 class probabilities
Output of matrix multiply: 1,000 units
Output of reshape to vector: 576 units
Output of pooling to 3x3 grid: 3x3x64
Output of convolution + ReLU: 64x64x64
Output of pooling with stride 4: 64x64x64
Output of convolution + ReLU: 256x256x64
Input image: 256x256x3
Output of softmax: 1,000 class probabilities
Output of average pooling: 1x1x1,000
Output of convolution: 16x16x1,000
Output of pooling with stride 4: 16x16x64
Output of convolution + ReLU: 64x64x64
Output of pooling with stride 4: 64x64x64
Output of convolution + ReLU: 256x256x64
Input image: 256x256x3


POOL
POOL
POOL
RELU
RELU
RELU
RELU
RELU
RELU
CONV
CONV
CONV
CONV
CONV
CONV
FC
car
truck
airplane
ship
horse


POOL
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FC
car
truck
airplane
ship
horse