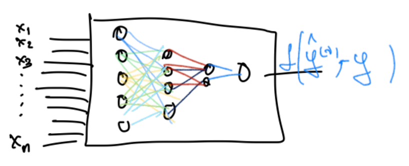
I) Given a image, we want to train a neuronal network for identify object in the image, for example a car, a cat etc. In this case the image have a border and different patron that we want to identify.

The neuronal network, dont identify patron because the train order is independ of value of in of neuronal network



We want to find the patter of image on the other way.. convolution neuronal network..

convolution Operation

$$\begin{bmatrix} 12 & 1 & 12 \\ 2 & 3 & 1 \\ 1 & 5 & 6 \end{bmatrix}_{3\times3} \circledast \begin{bmatrix} 1 & 0 & -1 \\ 1 & 0 & -1 \\ 1 & 0 & -1 \end{bmatrix}_{3\times3} = \cancel{12}\times1 + 1\times0 + \cancel{12}(-1) + 2\times1 + 3\times0 - 1 + 1 + 0\times5 + 6\times-1 = 2-\cancel{1}+\cancel{1}-6 = -4$$

$$= \boxed{-4}_{1\times1}.$$

II) dimension:

$3\times3 \circledast 3\times3 = 1\times1$

$\boxed{n\times n} \circledast \boxed{f\times f} = \boxed{n-f+1} \times \boxed{n-f+1}$

• PADDING:
When I have paddin (add zeros to image) we have the next dimension:

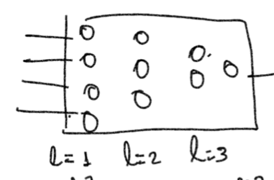
$\boxed{n+2p \times n+2p} * \boxed{f\times f} = \boxed{n+2p-f+1} \times \boxed{n+2p-f+1}$

• STRIDE OPERATION:
We can jump between operation

$$\left[\frac{n+2p-f}{s}+1\right] \times \left[\frac{n+2p-f}{s}+1\right]$$

$[2.4] = 2$
$[-2.4] = -3$

III) • ONE LAYER CNN.



$l=1$ $l=2$ $l=3$
$n^{[1]}=4$ $n^{[2]}=3$ $n^{[3]}=2$

$$Z^{[l]} = \omega^T A^{[l-1]} + b^{[l]}$$

When we have a nn, we obtain the output as a: $Z^{[l]} = \omega^T A^{[l-1]} + b^{[l]}$

$$Z^{[1]} = \omega^{[1]T} A^{[0]} + b^{[1]}$$

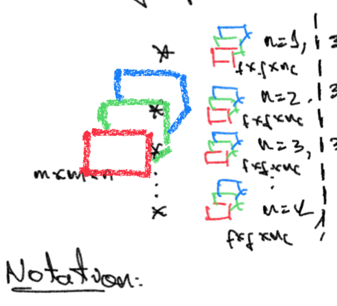
for CNN, we can optimize the filter parameter as following:

We can think in one image for understand the filter optimize with neuronal network.

Img $\circledast$ filter = Relu (Result + b)

$A^{[0]}$ W Relu $(\omega^{[1]T} A^{[0]} + b^{[1]})$

• Number of parameter in a cnn: $k=10$



$n=1$, $f\times f\times n_c$ | $3\times3\times3 = 27$
$n=2$, $f\times f\times n_c$ | $3\times3\times3 = 27$
$n=3$, $f\times f\times n_c$ | $3\times3\times3 = 27$
$n=k$, $f\times f\times n_c$ | $3\times3\times3 = 27$

Total parameter
$27\times10+10 = 280$

Notation:

• $f^{[l]}$: filter size
• $p^{[l]}$: padding
• $s^{[l]}$: stride
• $n_c^{[l]}$: Number of filter

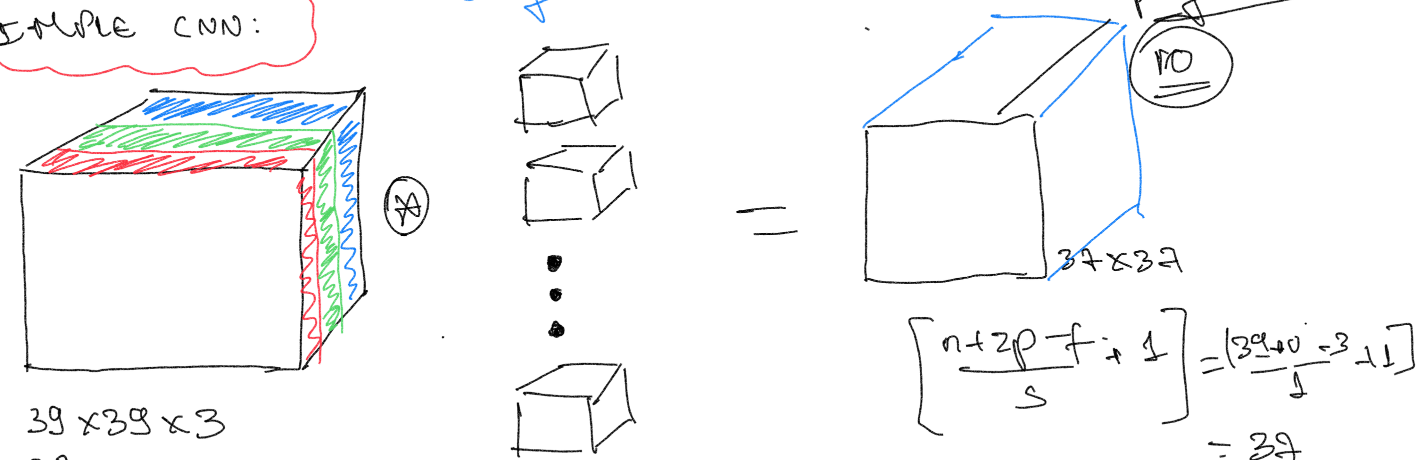
Input: $n_H^{[l-1]} \times n_H^{[l-1]} \times n_c^{[l-1]}$
Output: $n_H^{[l]} \times n_W^{[l]} \times n_c^{[l]}$

$$n_H^{[l]} = \left[\frac{n_H+2p-f}{s}+1\right]^{[l-1]}$$
$$n_W^{[l]} = \left[\frac{n_W+2p-f}{s}+1\right]^{[l-1]}$$

• each filter: $f^{[l]} \times f^{[l]} \times \boxed{n_c^{[l-1]}}$ · this value is the previous images.

• Activations: $\boxed{a^{[l]} = n_H^{[l]} \times n_W^{[l]} \times n_c^{[l]}}$
• Weight: $\boxed{f^{[l]} \times f^{[l]} \times n^{[l-1]}}$
• bias: $1, 1, 1, n_c^{[l]}$
• Code vectorize $\boxed{A^{[l]} = m \times n_H^{[l]} \times n_W^{[l]} \times n_c^{[l]}}$

IV) SIMPLE CNN:



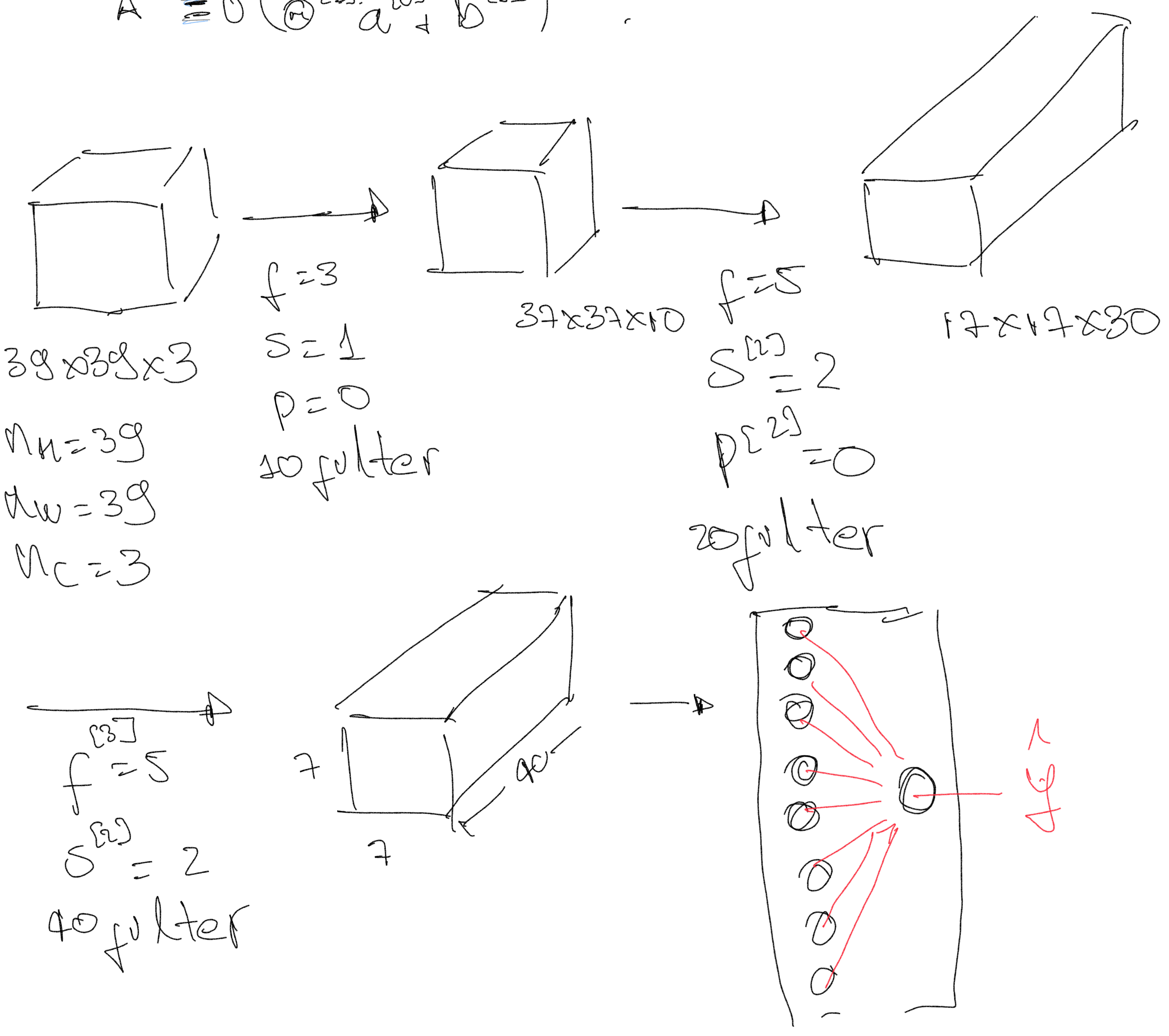
$39\times39\times3$
$n_H^{[0]} = 39$
$n_W^{[0]} = 39$
$n_c^{[0]} = 3$

$f^{[1]} = 3$
$s^{[1]} = 1$
$p^{[1]} = 0$

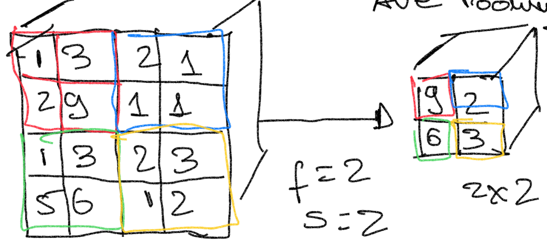
$$\left[\frac{n+2p-f}{s}+1\right] = \left[\frac{39+0-3}{1}+1\right] = 37$$

$A^{[1]}$.

$$A^{[1]} = \sigma(\omega^{[1]} a^{[0]} + b^{[1]})$$

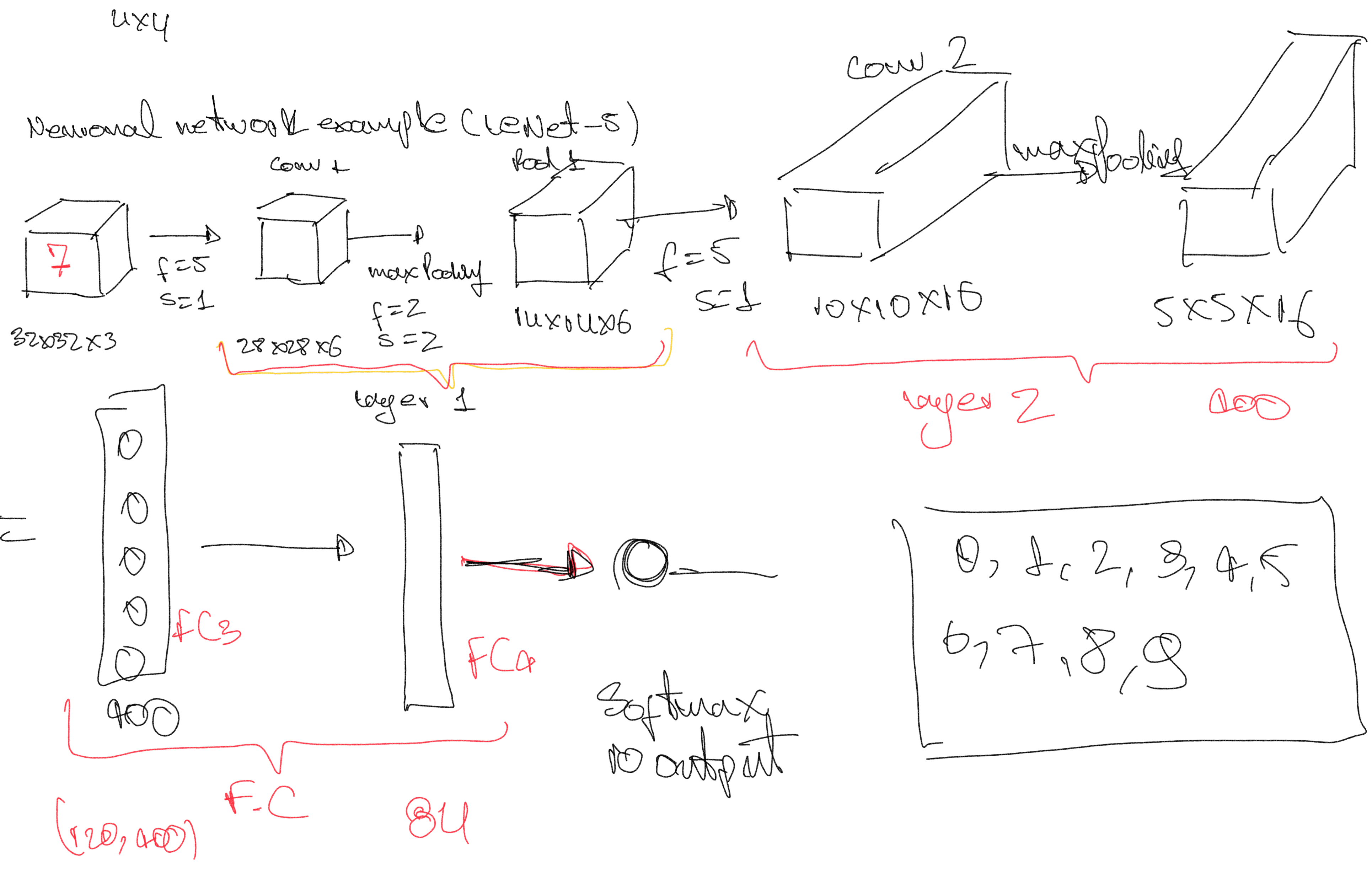


V) POOLING LAYER (Max Pooling / Ave Pooling) (No parameter to learn)



$$\left[\frac{n+2p-f}{s}+1\right]$$

VI) Neuronal network example (LeNet-5)



◦ AlexNet
◦ VGG
◦ Residual N

$$z^{[l+1]} = W^{[l+1]} a^{[l]} + b^{[l+1]}$$
$$a^{[l+1]} = g(z^{[l+1]})$$
$$z^{[l+2]} = W^{[l+2]} a^{[l+1]} + b^{[l+2]}$$
$$a^{[l+2]} = g[z^{[l+2]} + a^{[l]}]$$