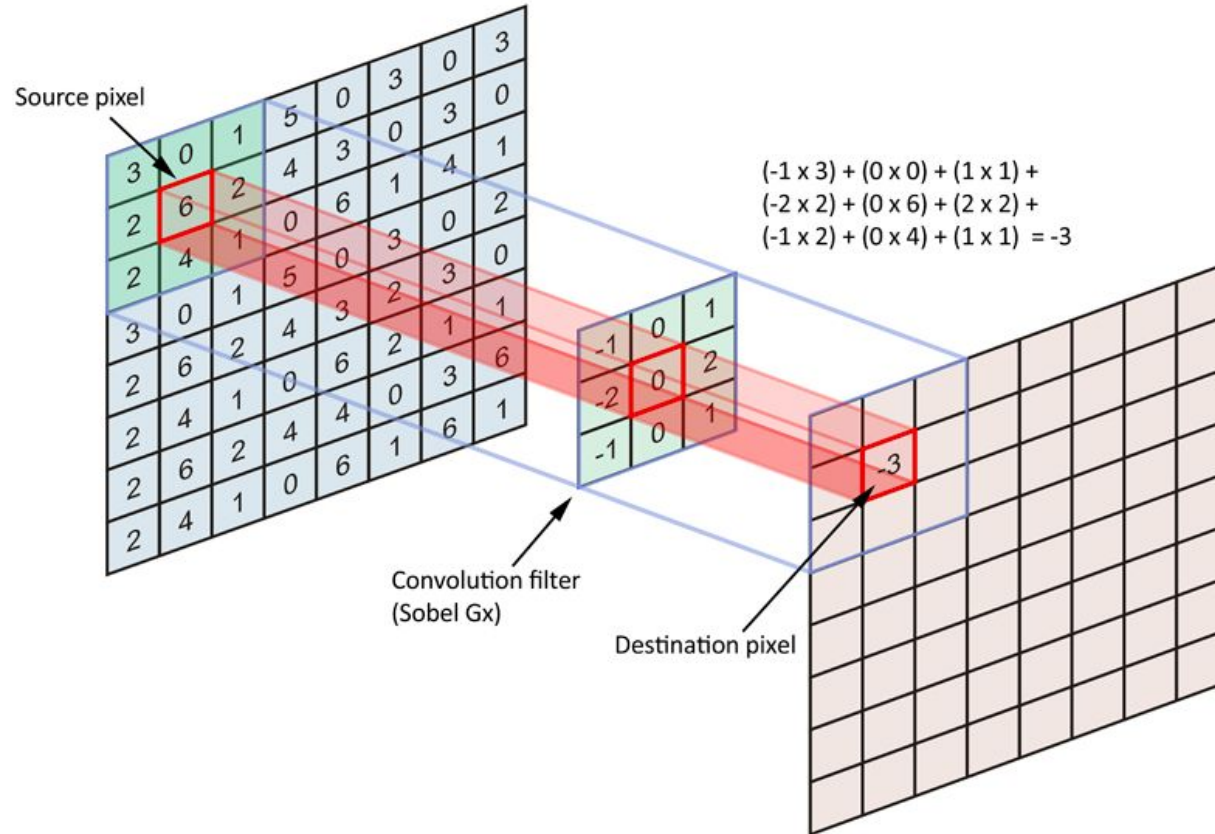


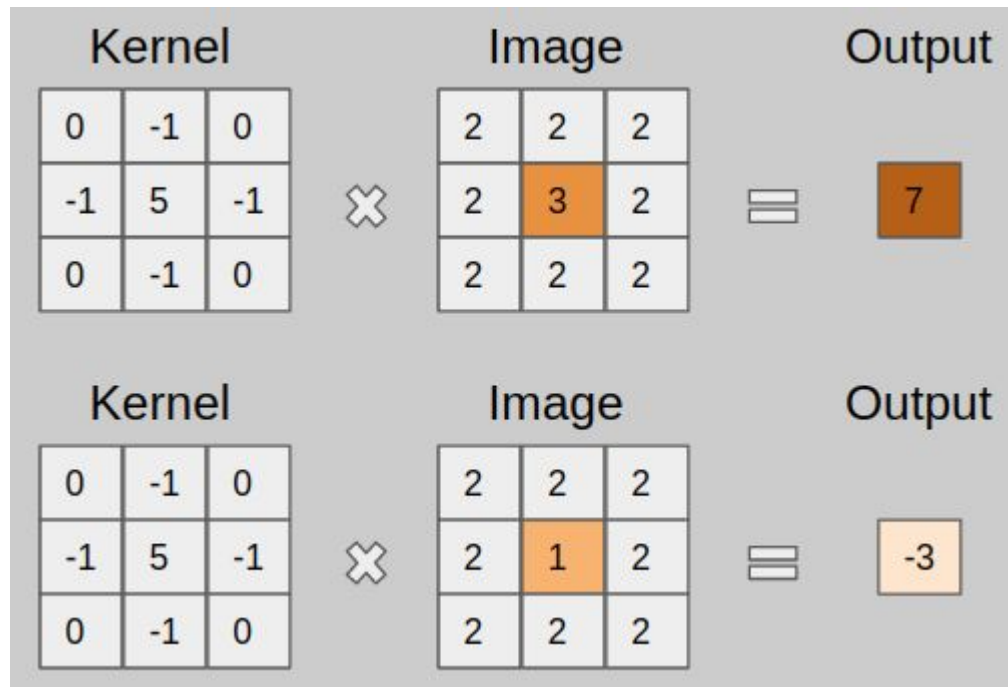
# CNN

Extração de características

# CNN - Kernels



# CNN - Convolução



# CNN

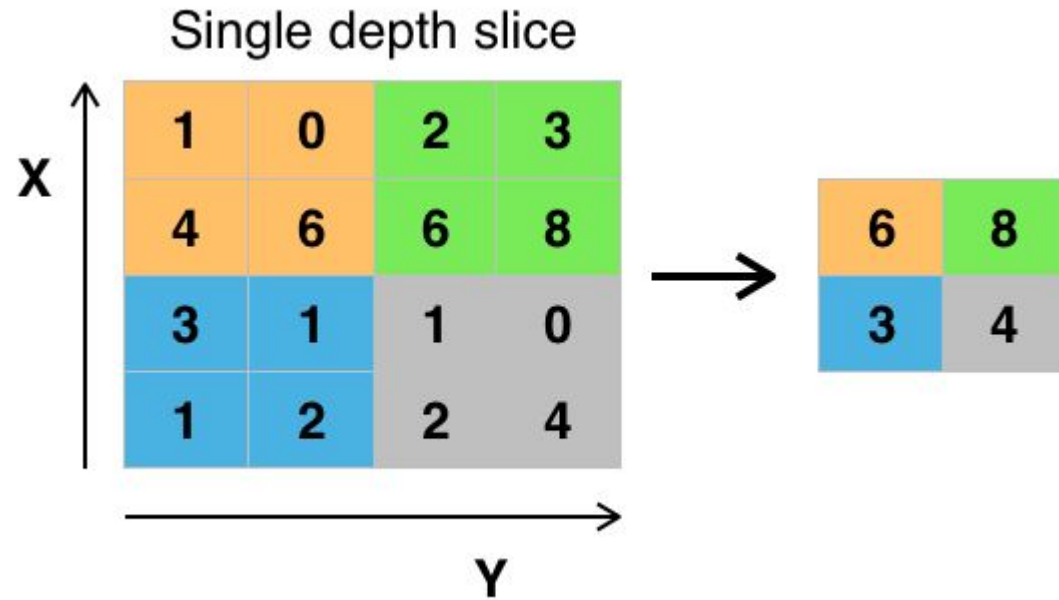
Original Image



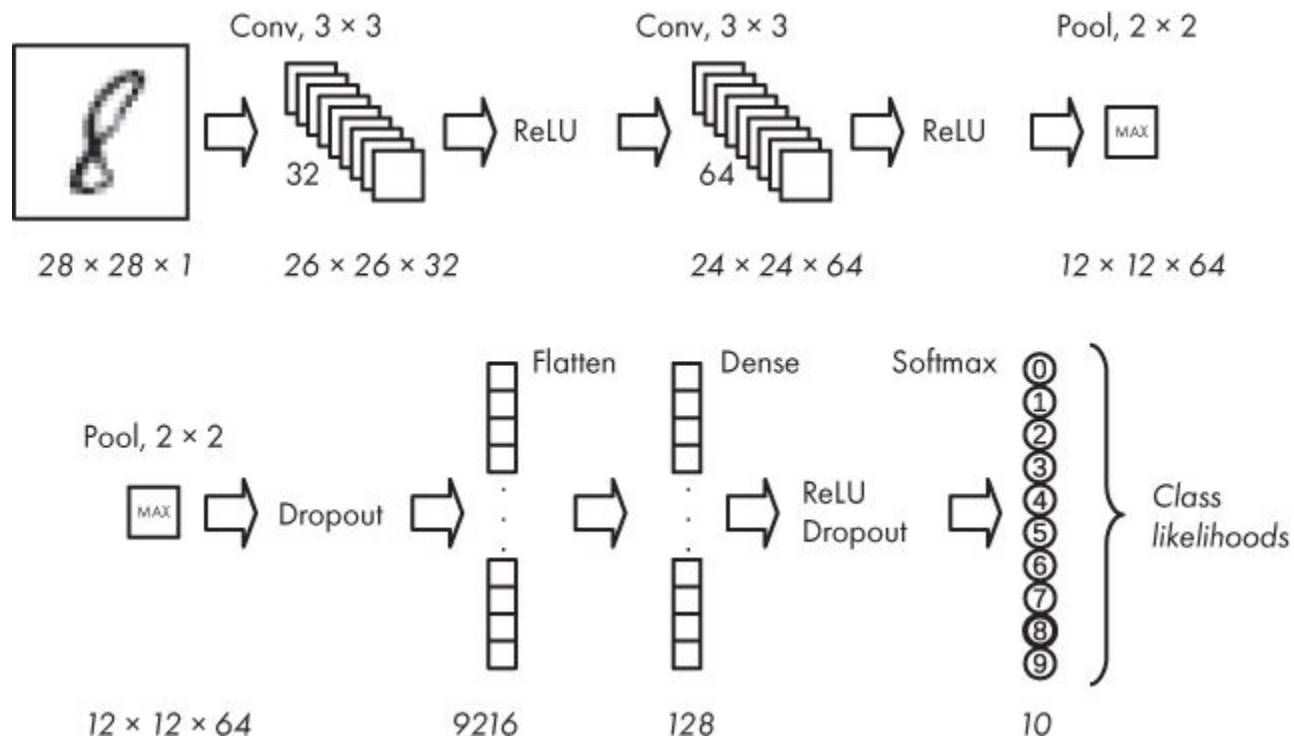
Sobel Edge Detection



# CNN - Pooling



# CNN



## Exemplo - Convolução

$$0: \begin{bmatrix} -1 & 2 & 2 & -2 & -2 \\ -1 & 0 & 2 & 0 & 2 \\ 1 & 2 & 2 & 1 & -2 \\ -1 & 2 & 2 & 2 & 2 \\ 1 & -1 & 1 & 0 & -1 \end{bmatrix}$$

$$1: \begin{bmatrix} 2 & -2 & -1 & -2 & -2 \\ 1 & 1 & 2 & 1 & -2 \\ 2 & 2 & -1 & -1 & 0 \\ -1 & -1 & 2 & -2 & 2 \\ -1 & -2 & 0 & -2 & 0 \end{bmatrix}$$

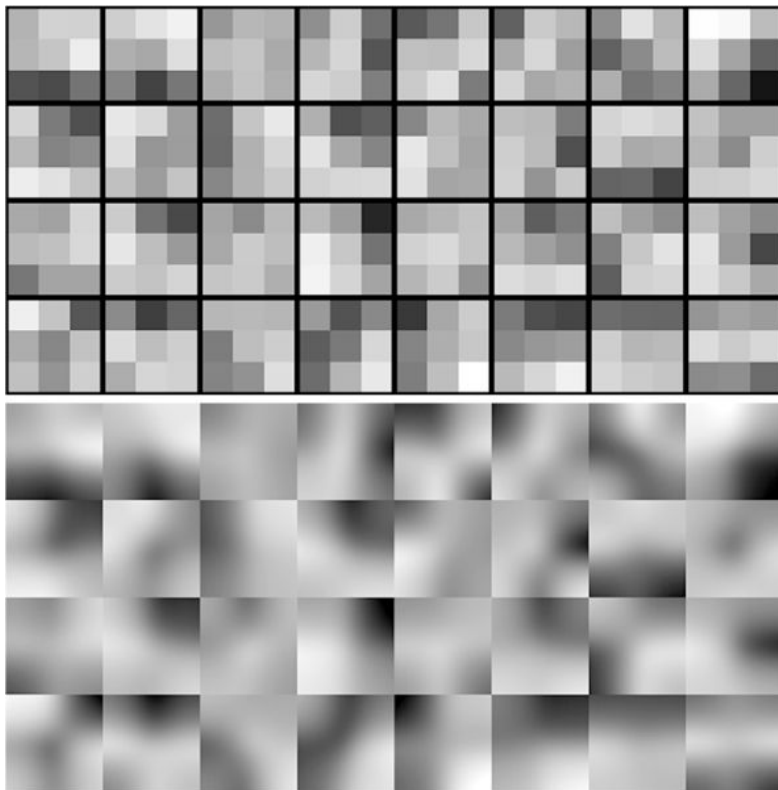
$$0: \begin{matrix} & k_0 \\ \begin{bmatrix} 1 & -1 & 1 \\ 1 & -1 & 0 \\ -1 & -1 & 1 \end{bmatrix} & \begin{bmatrix} 0 & -1 & 0 \\ -1 & 1 & -1 \\ -1 & 1 & 0 \end{bmatrix} & \begin{bmatrix} 1 & 0 & 0 \\ -1 & 0 & 0 \\ 0 & -1 & 0 \end{bmatrix} \end{matrix}$$
$$1: \begin{matrix} \begin{bmatrix} -1 & 0 & 0 \\ 1 & 1 & -1 \\ 0 & 0 & 1 \end{bmatrix} & \begin{bmatrix} 0 & 1 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 0 \end{bmatrix} & \begin{bmatrix} -1 & 1 & 1 \\ 1 & 0 & 1 \\ -1 & 0 & 0 \end{bmatrix} \end{matrix}$$

## CNN - Exemplo

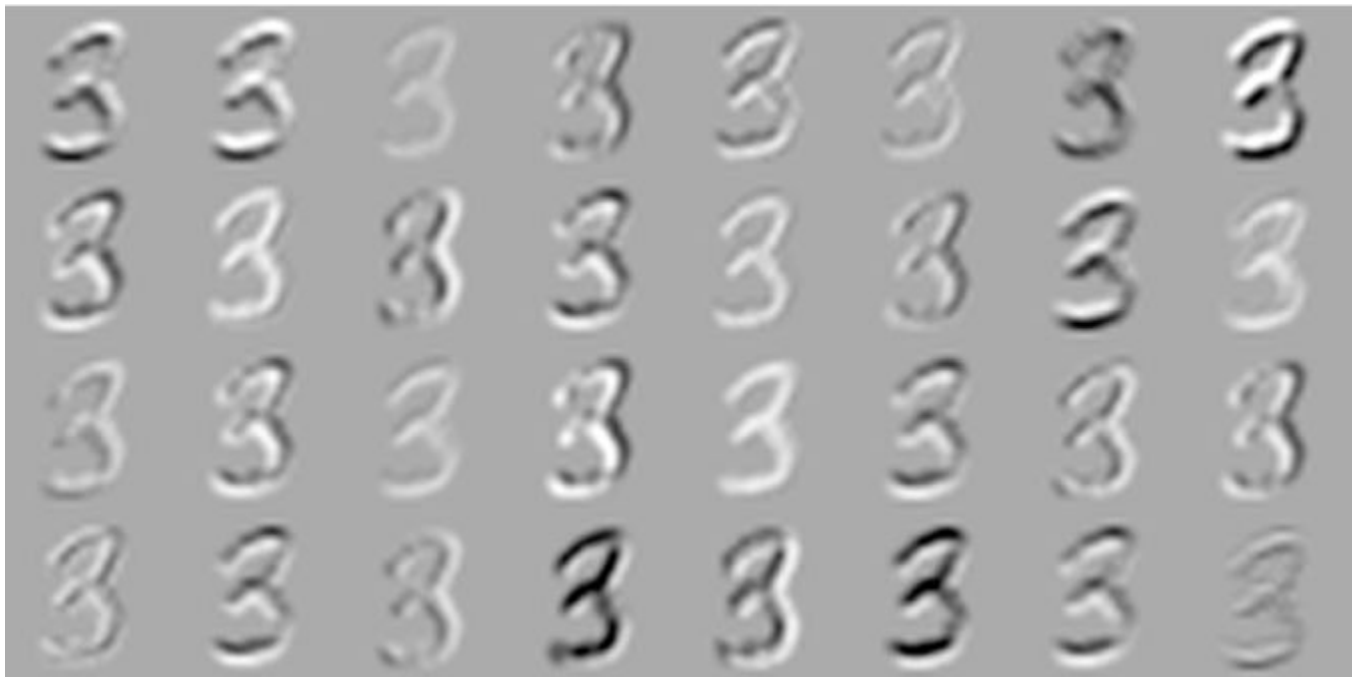
$$\begin{bmatrix} -1 & 2 & 2 & -2 & -2 \\ -1 & 0 & 2 & 0 & 2 \\ 1 & 2 & 2 & 1 & -2 \\ -1 & 2 & 2 & 2 & 2 \\ 1 & -1 & 1 & 0 & -1 \end{bmatrix} * \begin{bmatrix} 1 & -1 & 1 \\ 1 & -1 & 0 \\ -1 & -1 & 1 \end{bmatrix} = \begin{bmatrix} -3 & -7 & -1 \\ 1 & -4 & 3 \\ -1 & 1 & -3 \end{bmatrix}$$



# CNN



CNN





Low-Level  
Feature

Mid-Level  
Feature

High-Level  
Feature

Trainable  
Classifier

