

# < Forward Pass >

Input (5x5)

$x_{11}$	$x_{12}$	$x_{13}$	$x_{14}$	$x_{15}$
$x_{21}$	$x_{22}$	$x_{23}$	$x_{24}$	$x_{25}$
$x_{31}$	$x_{32}$	$x_{33}$	$x_{34}$	$x_{35}$
$x_{41}$	$x_{42}$	$x_{43}$	$x_{44}$	$x_{45}$
$x_{51}$	$x_{52}$	$x_{53}$	$x_{54}$	$x_{55}$

Filter (4x4)

$w_{11}$	$w_{12}$	$w_{13}$	$w_{14}$
$w_{21}$	$w_{22}$	$w_{23}$	$w_{24}$
$w_{31}$	$w_{32}$	$w_{33}$	$w_{34}$
$w_{41}$	$w_{42}$	$w_{43}$	$w_{44}$

\*

Conv

Output (2x2)

$(a_{11} > a_{12}, a_{22} > a_{21} \text{ 이라 가정.})$

$\sum_{i=1}^4 \sum_{j=1}^4 x_{i,j} w_{ij} = a_{11}$	$\sum_{i=1}^4 \sum_{j=1}^4 x_{i,j+1} w_{ij} = a_{12}$
$\sum_{i=1}^4 \sum_{j=1}^4 x_{i+1,j} w_{ij} = a_{21}$	$\sum_{i=1}^4 \sum_{j=1}^4 x_{i+1,j+1} w_{ij} = a_{22}$

Max Pooling  
(1x2)

$\max(a_{11}, a_{12}) = g_1$
$\max(a_{21}, a_{22}) = g_2$

(filter 가로길이 - 1)

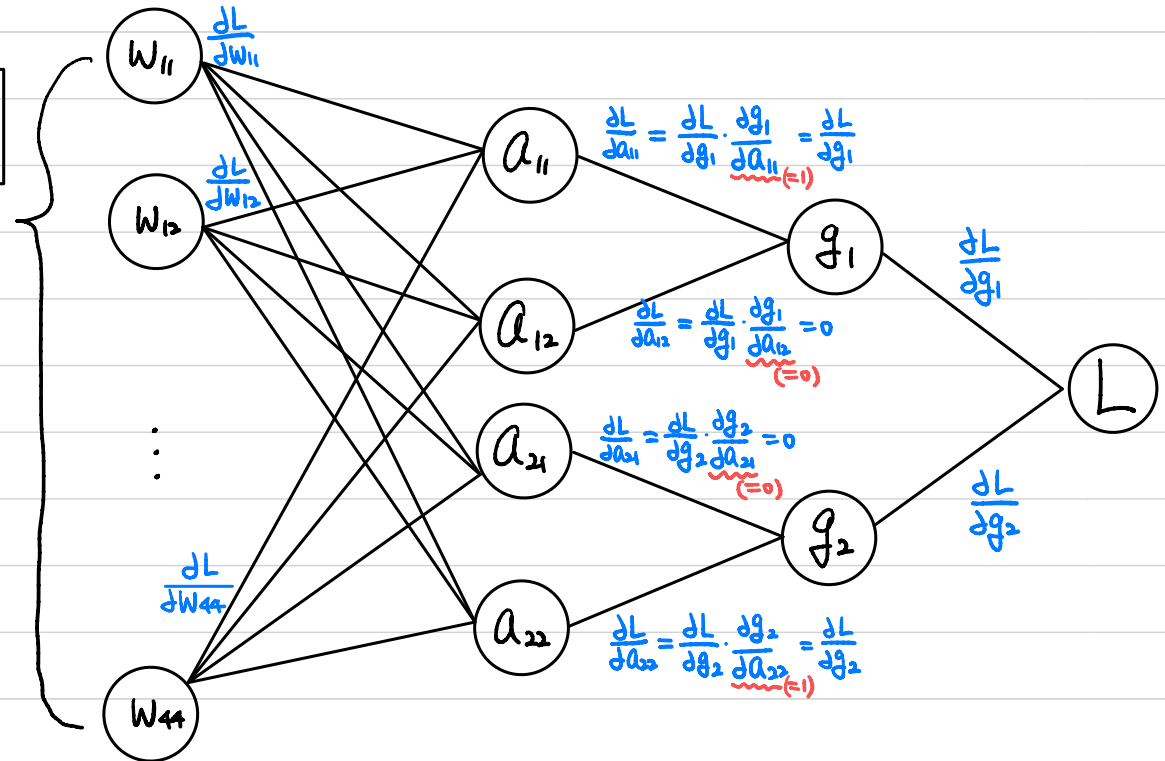
$$a_{ij} = \sum_{a=0}^3 \sum_{b=0}^3 x_{(i+a, j+b)} \cdot w_{(a,b)} \quad (\text{4x4})$$

$$g(x) = \begin{cases} \max(x) & (\text{if } x > 0) \\ 0 & (\text{otherwise}) \end{cases}$$

$$\frac{\partial g}{\partial x} = \begin{cases} 1 \\ 0 \end{cases}$$

$$\begin{aligned} \frac{\partial L}{\partial w_{11}} &= \frac{\partial L}{\partial g_1} \cdot \frac{\partial g_1}{\partial a_{11}} \cdot \frac{\partial a_{11}}{\partial w_{11}} = x_{11} \\ &+ \frac{\partial L}{\partial g_1} \cdot \frac{\partial g_1}{\partial a_{12}} \cdot \frac{\partial a_{12}}{\partial w_{11}} = x_{12} \\ &+ \frac{\partial L}{\partial g_2} \cdot \frac{\partial g_2}{\partial a_{21}} \cdot \frac{\partial a_{21}}{\partial w_{11}} = x_{21} \\ &+ \frac{\partial L}{\partial g_2} \cdot \frac{\partial g_2}{\partial a_{22}} \cdot \frac{\partial a_{22}}{\partial w_{11}} = x_{22} \\ &= \sum_{i=1}^2 \sum_{j=1}^2 \frac{\partial L}{\partial g_i} \cdot \frac{\partial g_i}{\partial a_{ij}} \cdot x_{ij} \end{aligned}$$

총 16개의  
가중치



# < CNN Back-Propagation >