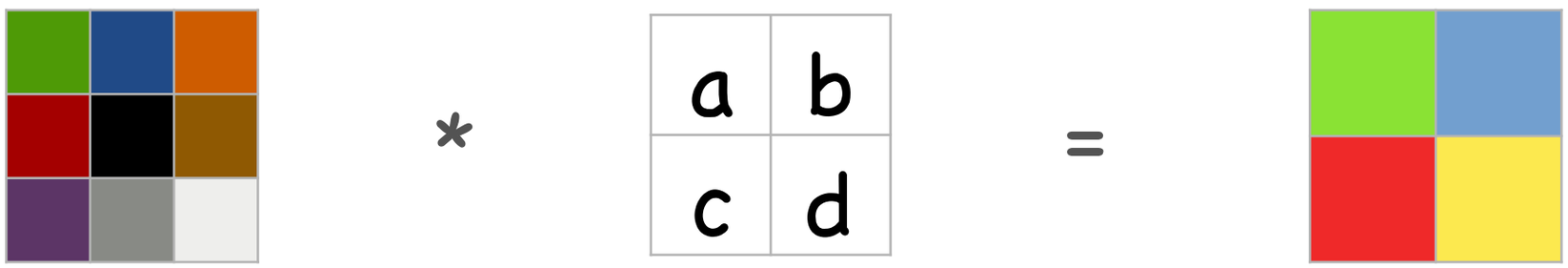
Convolutional operators and their structure

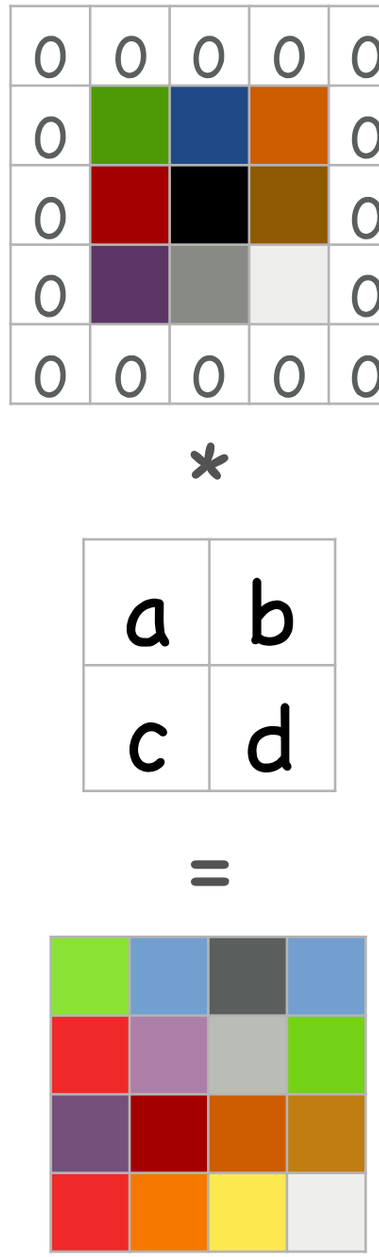
Output size

- Input: $\mathbf{X} \in \mathbb{R}^{H \times W \times C_1}$
- Kernel: $\mathbf{w} \in \mathbb{R}^{h \times w \times C_1 \times C_2}$
- Output: $\mathbf{Z} \in \mathbb{R}^{(H-h+1) \times (W-w+1) \times C_2}$



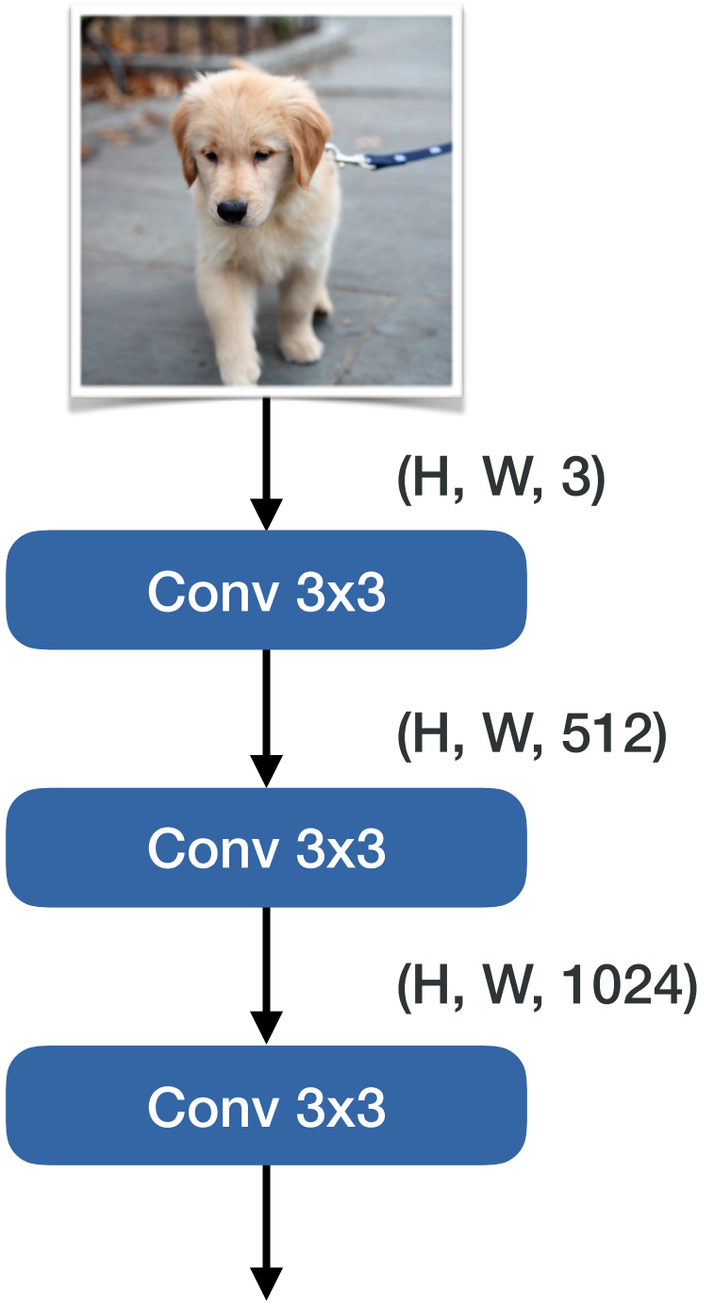
Padding

- Add p_w, p_h zeros in each dimension
- Input: $\mathbf{X} \in \mathbb{R}^{H \times W \times C_1}$
- Kernel: $\mathbf{w} \in \mathbb{R}^{h \times w \times C_1 \times C_2}$
- Output: $\mathbf{Z} \in \mathbb{R}^{(H-h+2p_h+1) \times (W-w+2p_w+1) \times C_2}$



Output resolution

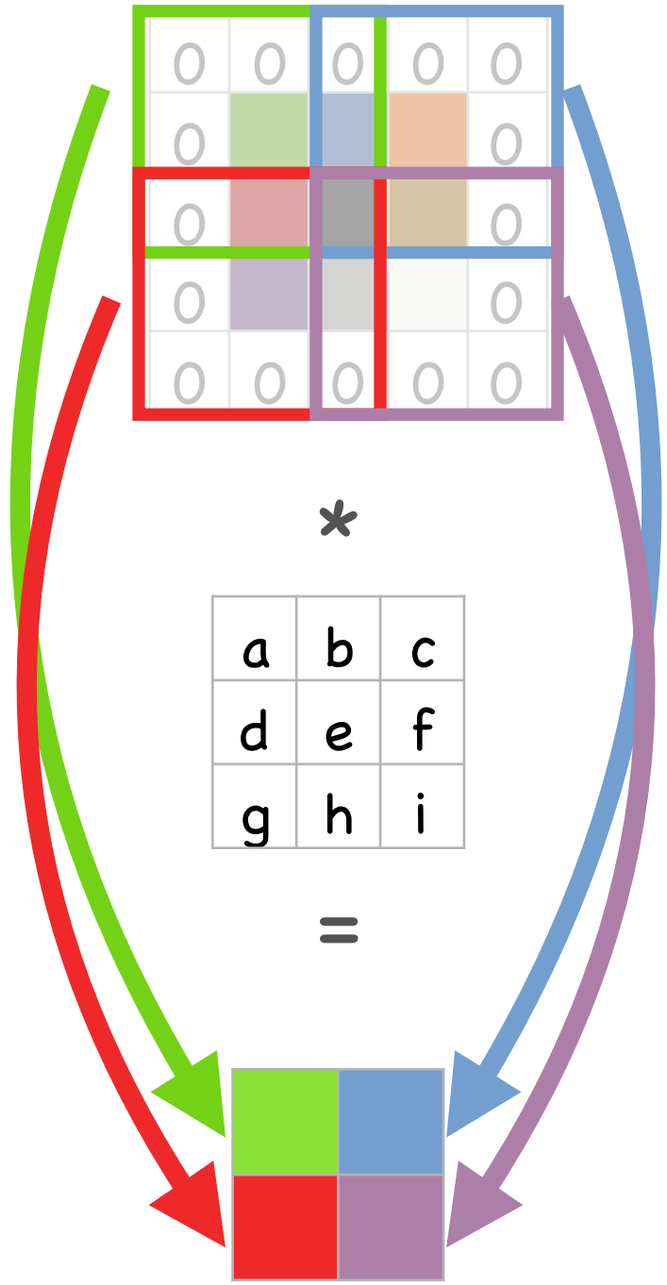
- High output resolution
  - Slow computation



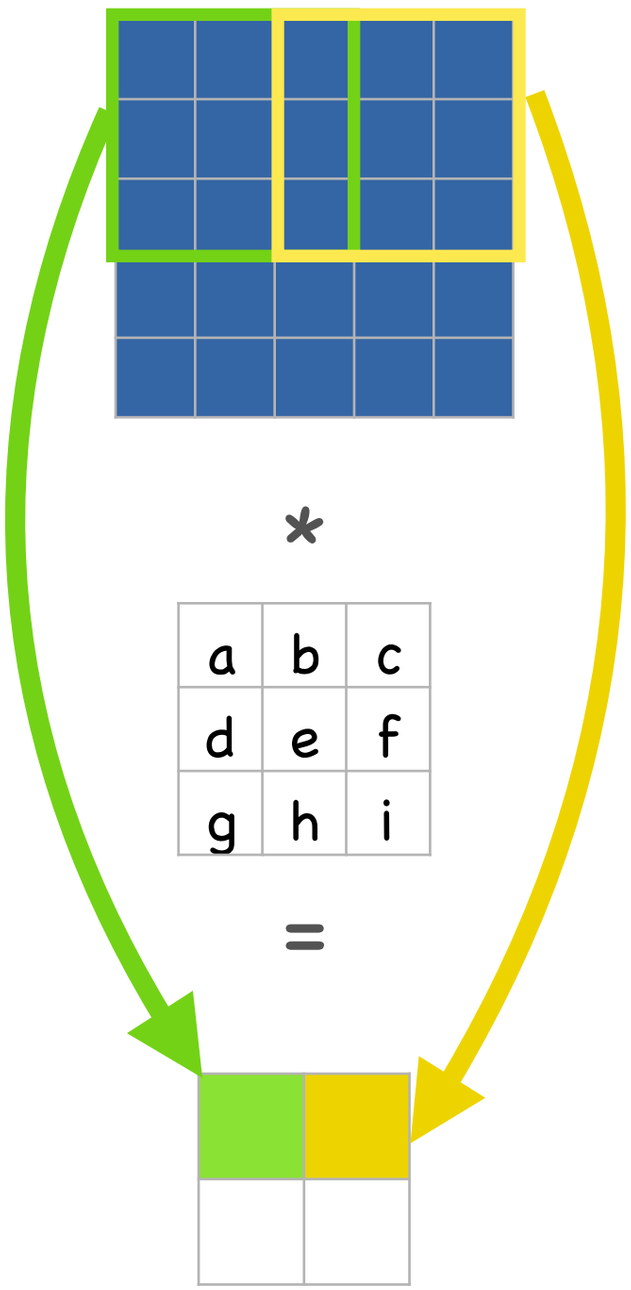
Striding

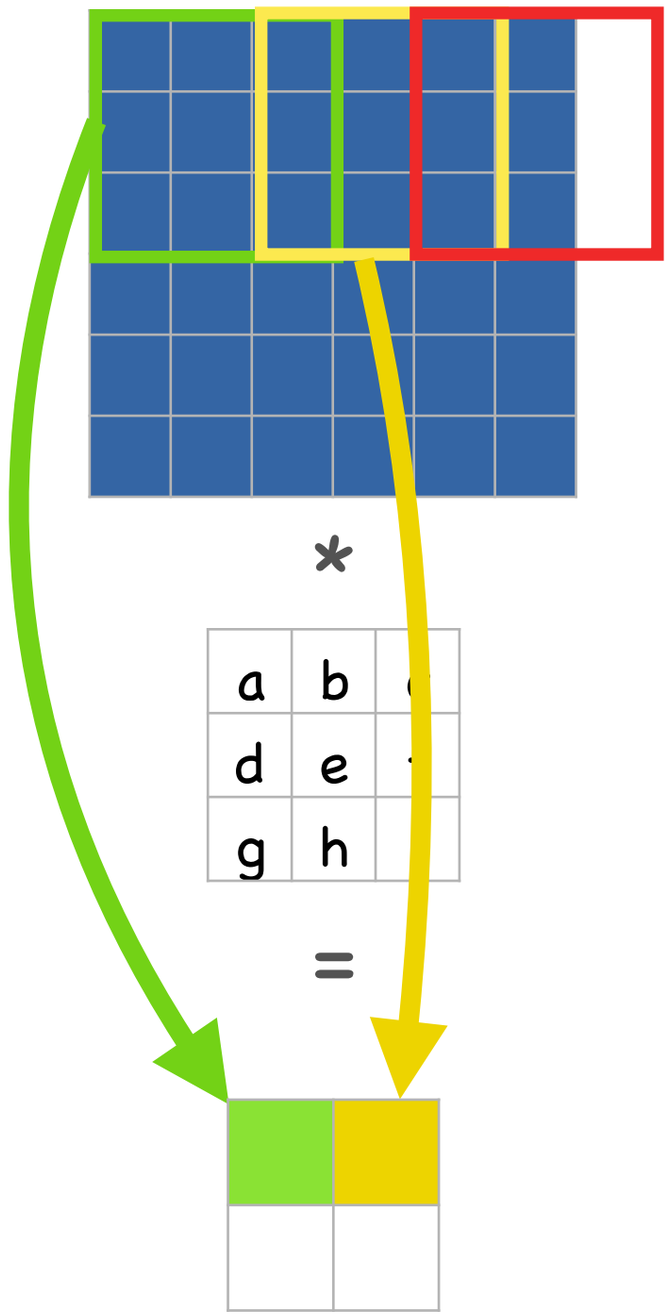
- Only compute every n-th output: s_w, s_h
- Input: $\mathbf{X} \in \mathbb{R}^{H \times W \times C_1}$
- Kernel: $\mathbf{w} \in \mathbb{R}^{h \times w \times C_1 \times C_2}$
- Output:

$$\mathbf{Z} \in \mathbb{R}^{\left(\frac{H-h+2p_h}{s_h}+1\right) \times \left(\frac{W-w+2p_w}{s_w}+1\right) \times C_2}$$



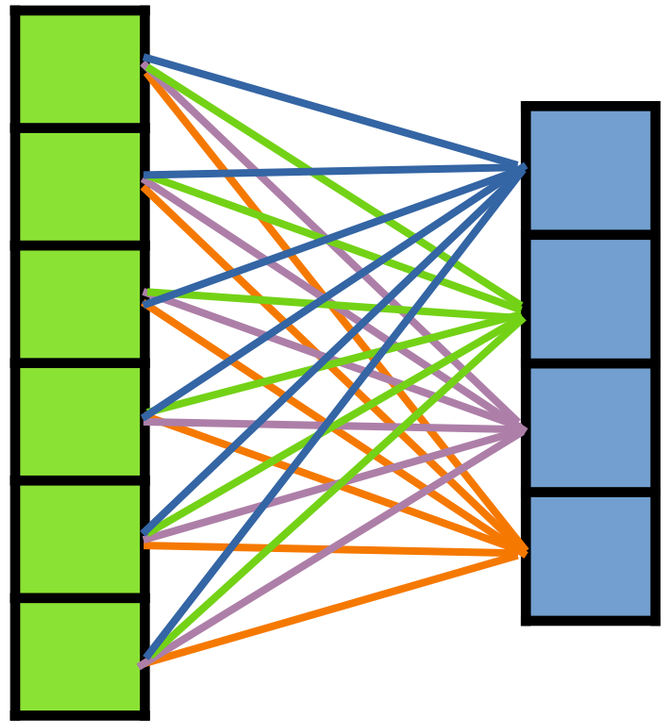
Output size with striding





Parameters

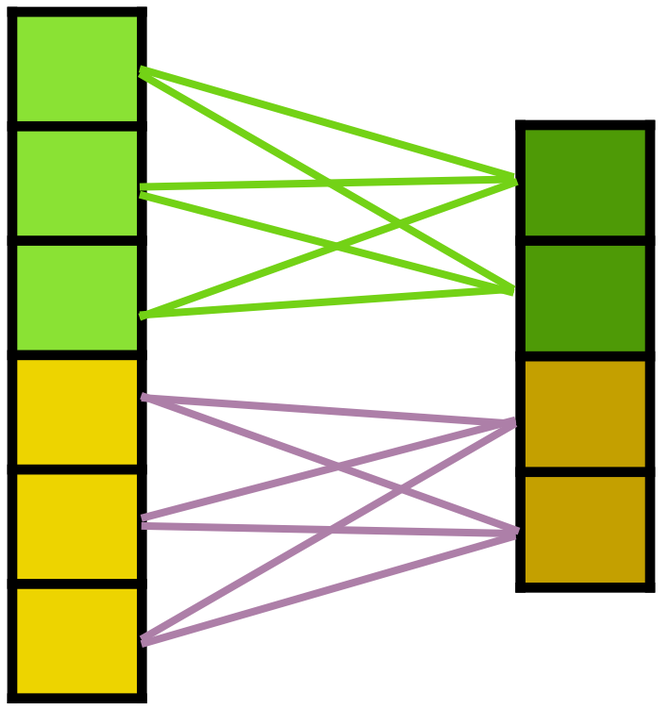
- Every input channel C_1 is connected to every output channel C_2



$C_1 = 6$ $C_2 = 4$

Grouping

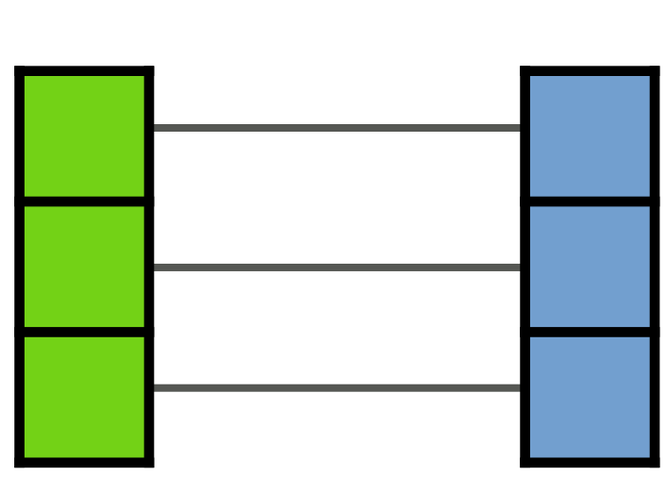
- Split channels into g groups
- Reduce parameters and computation by factor g



$C_1 = 6$ $C_2 = 4$

Depthwise convolution

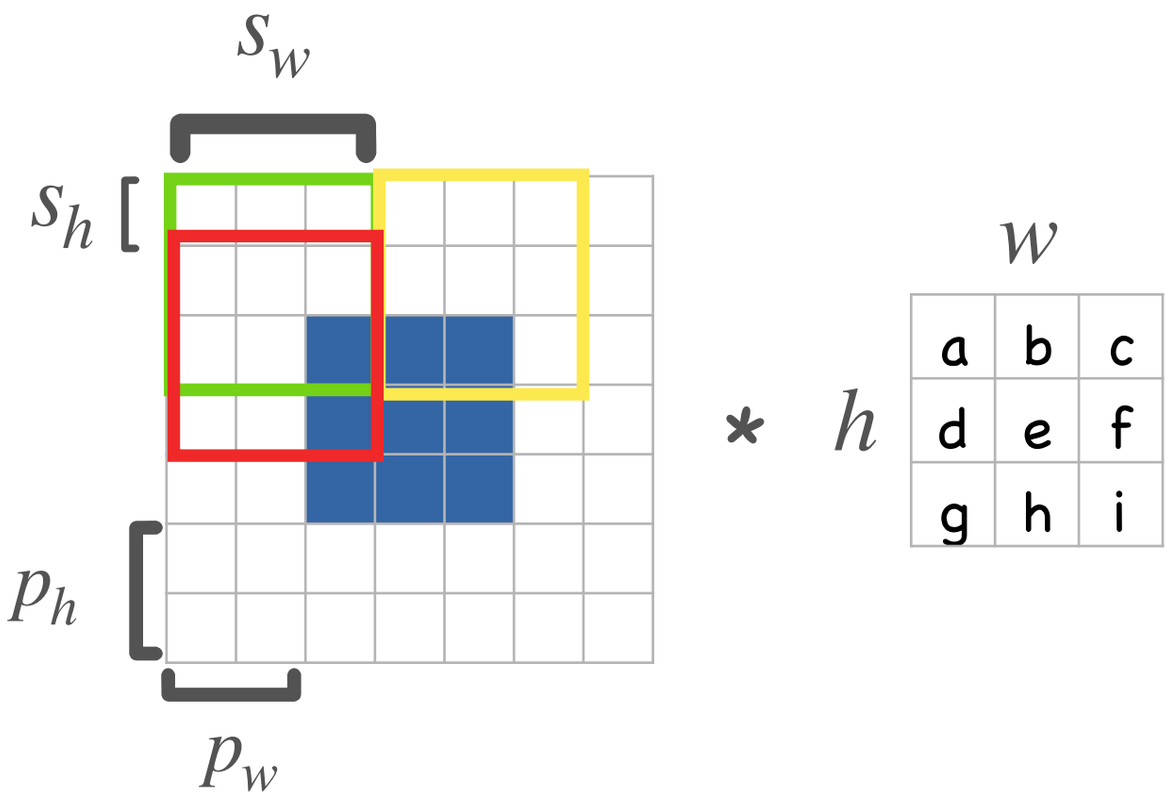
- Special grouping
  - $C_1 = g$
  - $C_2 = g$



$C_1 = 3$ $C_2 = 3$

Hyper-parameters of convolutions

- Kernel size: $w \times h$
- Padding: p_w , p_h
- Stride: s_w , s_h



Convolutional operators

- Run arbitrary operation $f(\mathbf{x})$ "over" image

$f(\mathbf{x})$

$*$

a	b	c
d	e	f
g	h	i

$=$