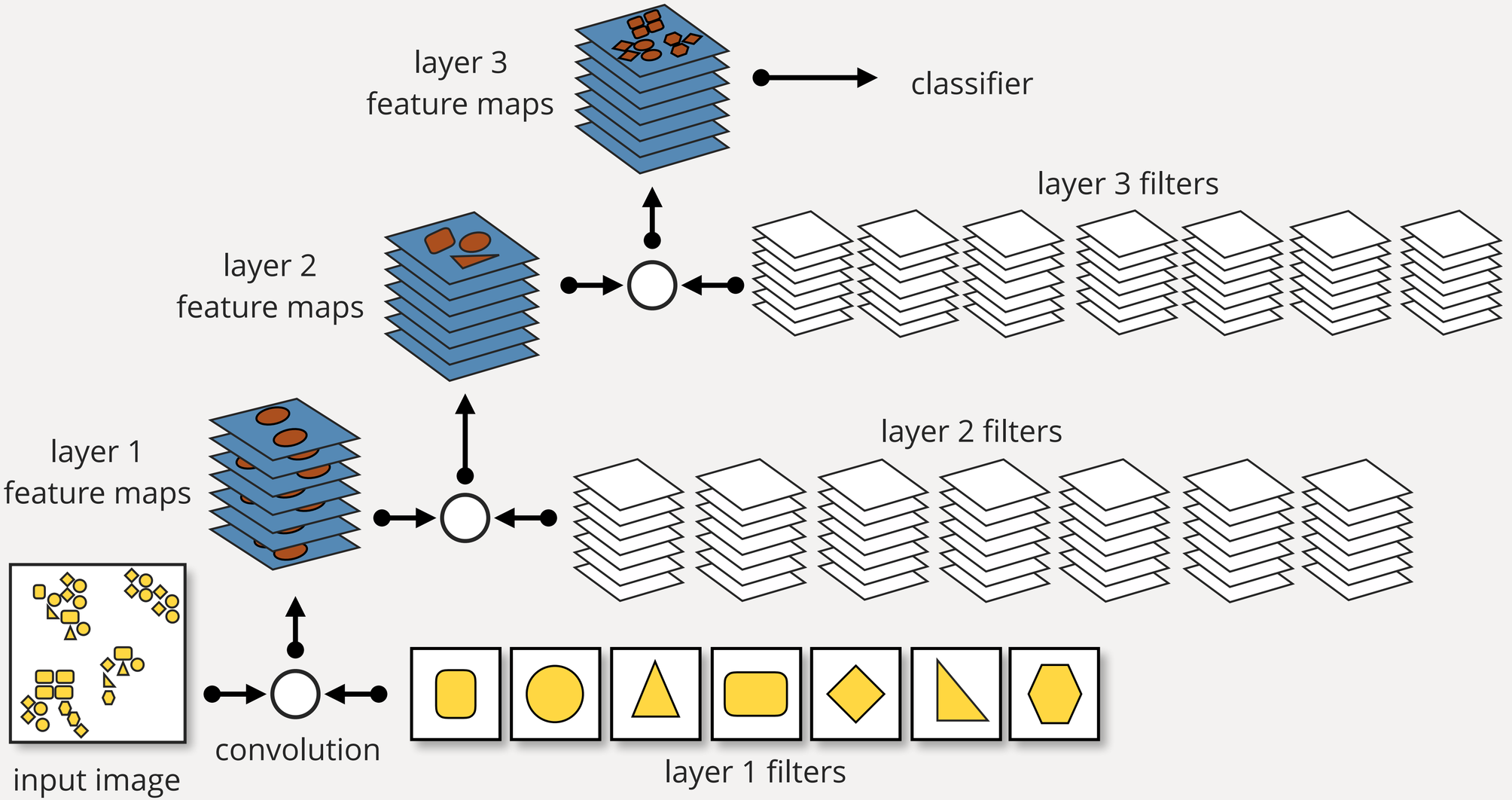
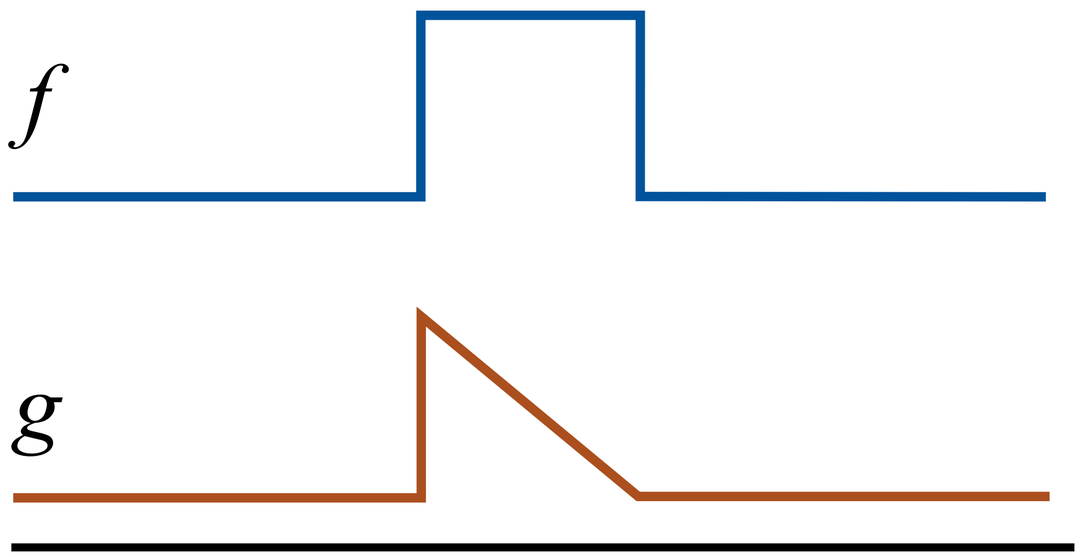
Breakdown of the Convolution (1D and 2D)

Convolutional Neural Network

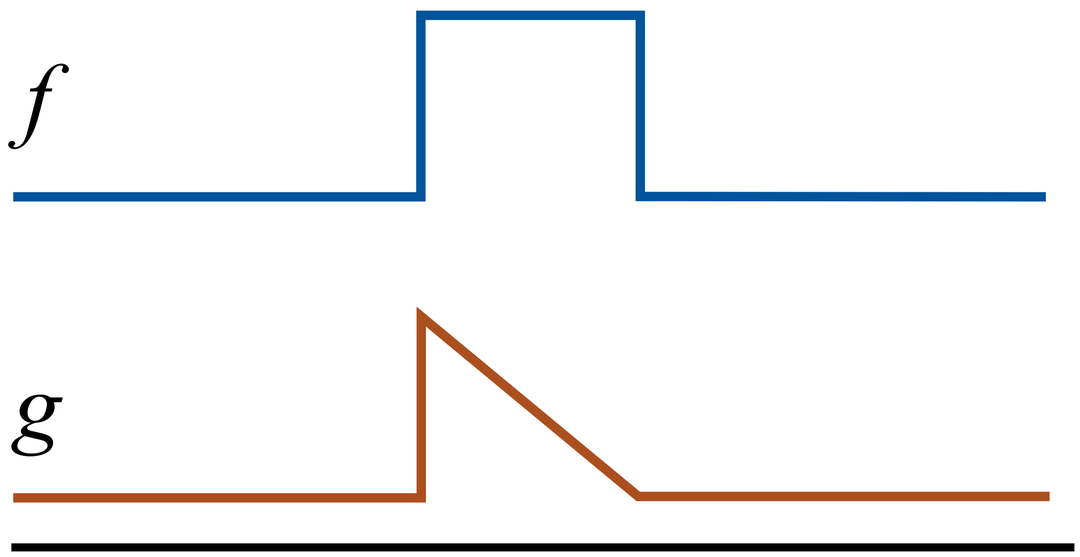


1D Spatial Convolution



$$(f \times g)[n] = \sum_{m=-\infty}^{\infty} f[m]g[n-m]$$

1D Spatial Convolution



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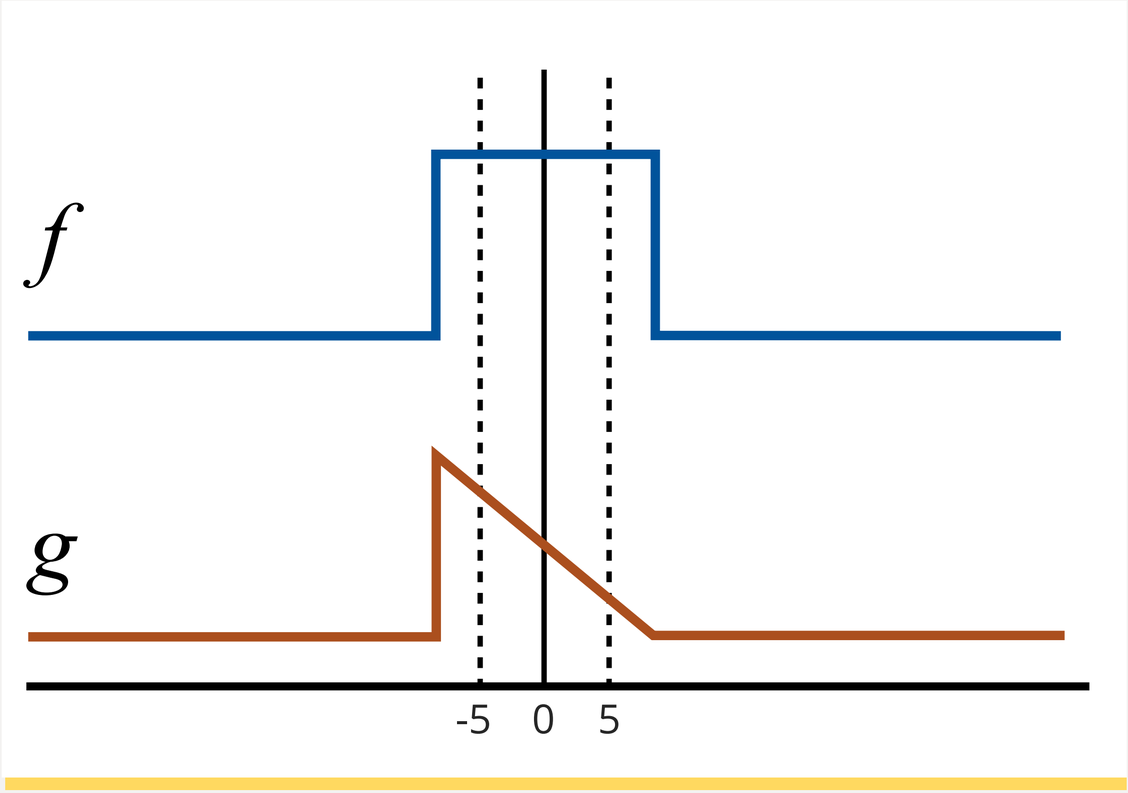
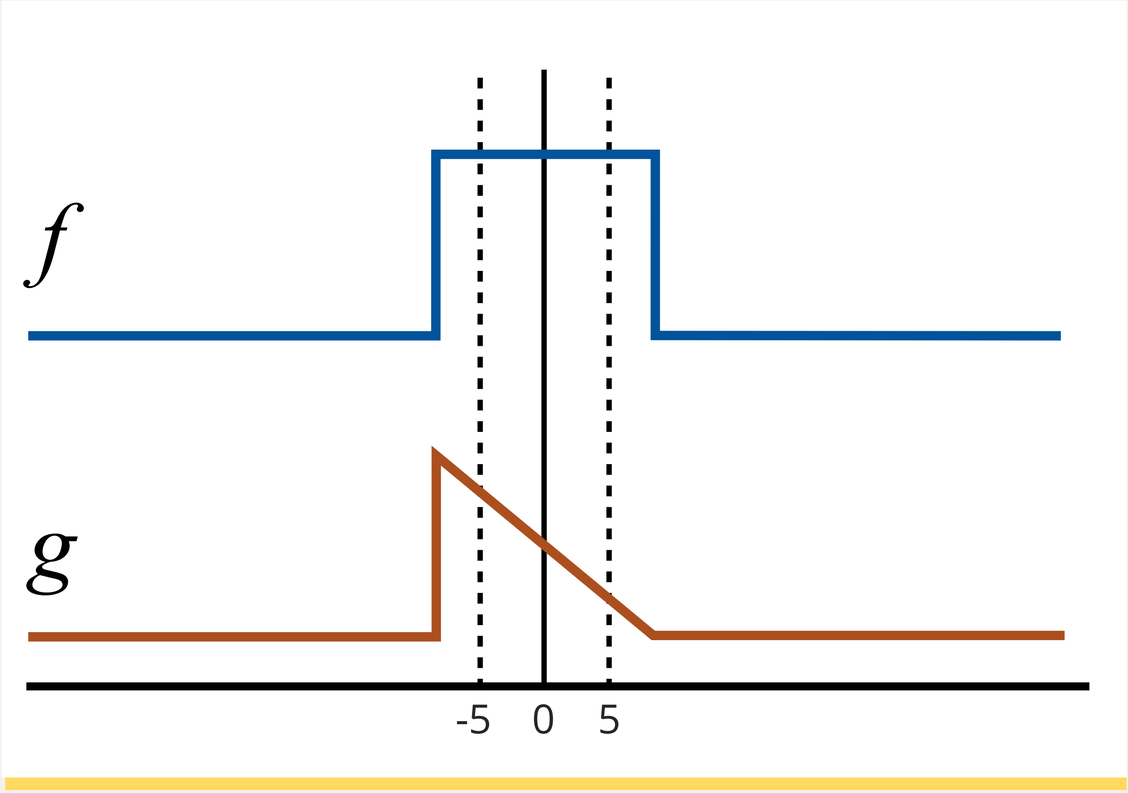
1D Spatial Convolution

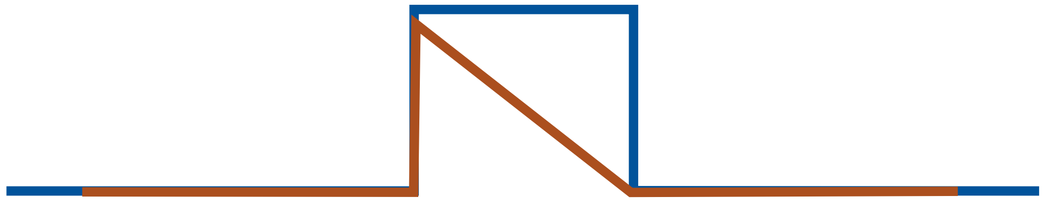


$$(f \times g)[n] = \sum_{m=-\infty}^{\infty} f[m]g[n-m]$$

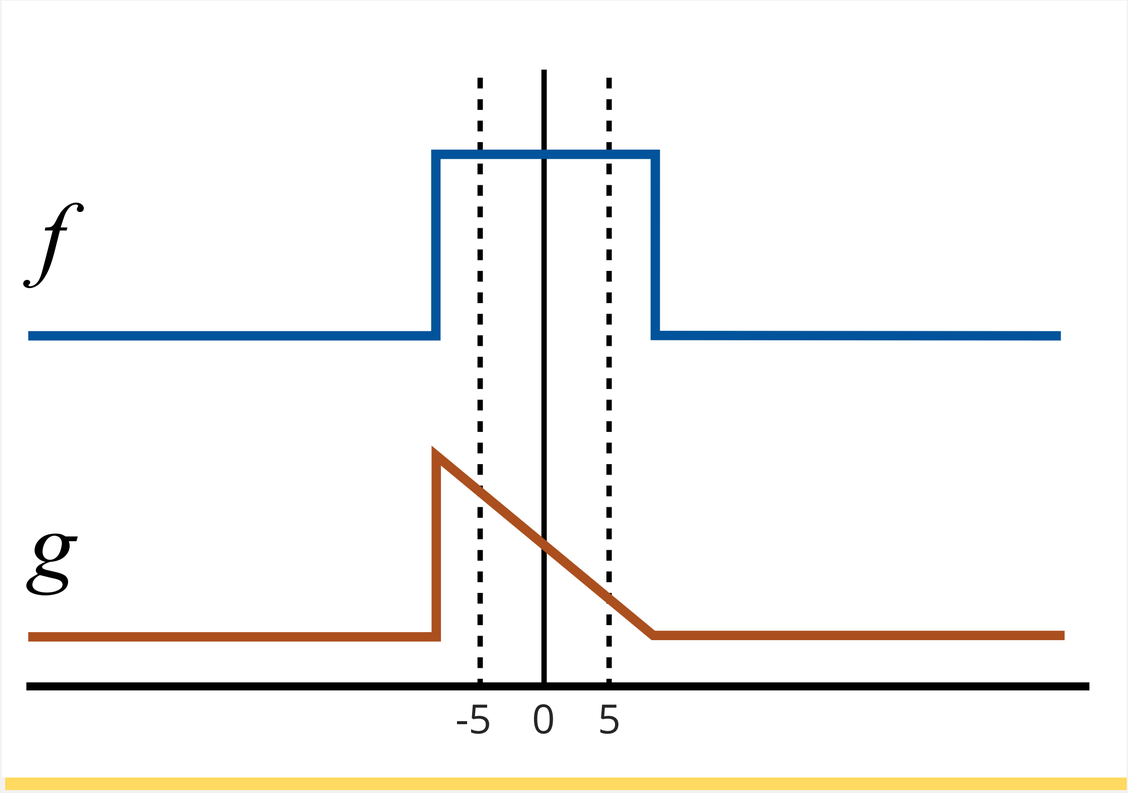
1D Spatial Convolution



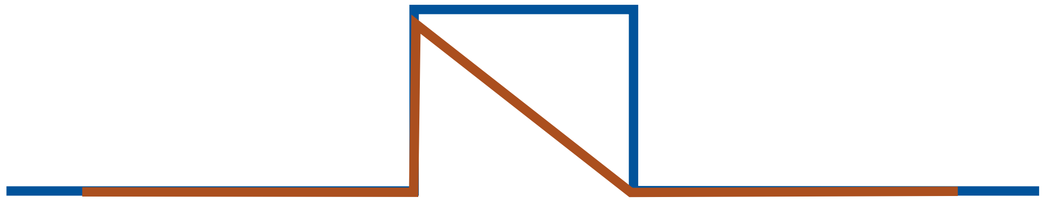
$$(f \times g)[n] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(n+m)]$$



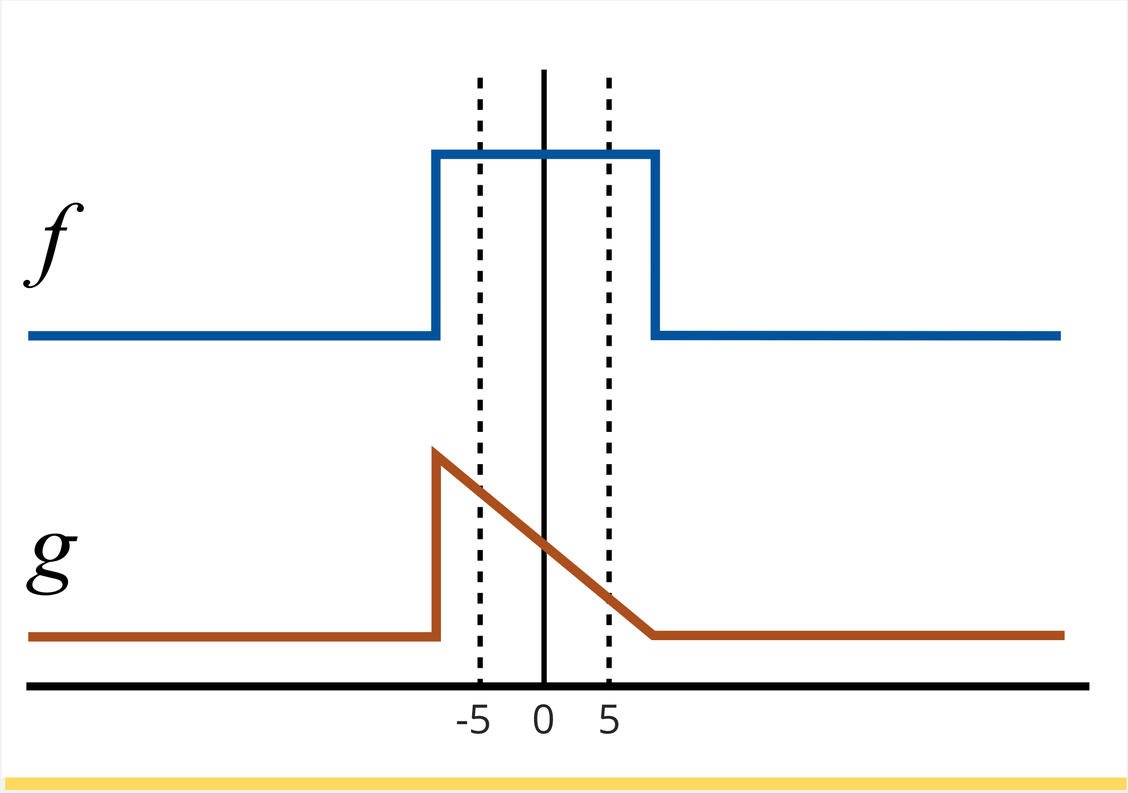
1D Spatial Convolution



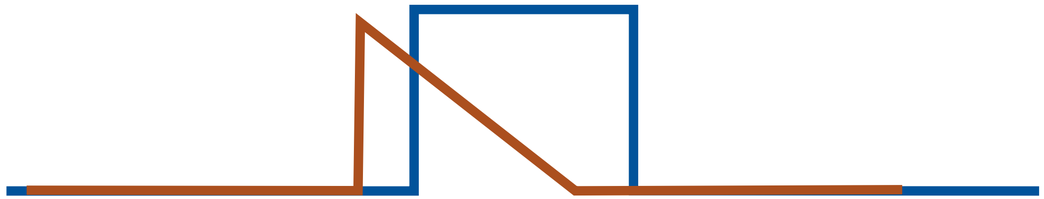
$$(f \times g)[-5] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(5+m)]$$



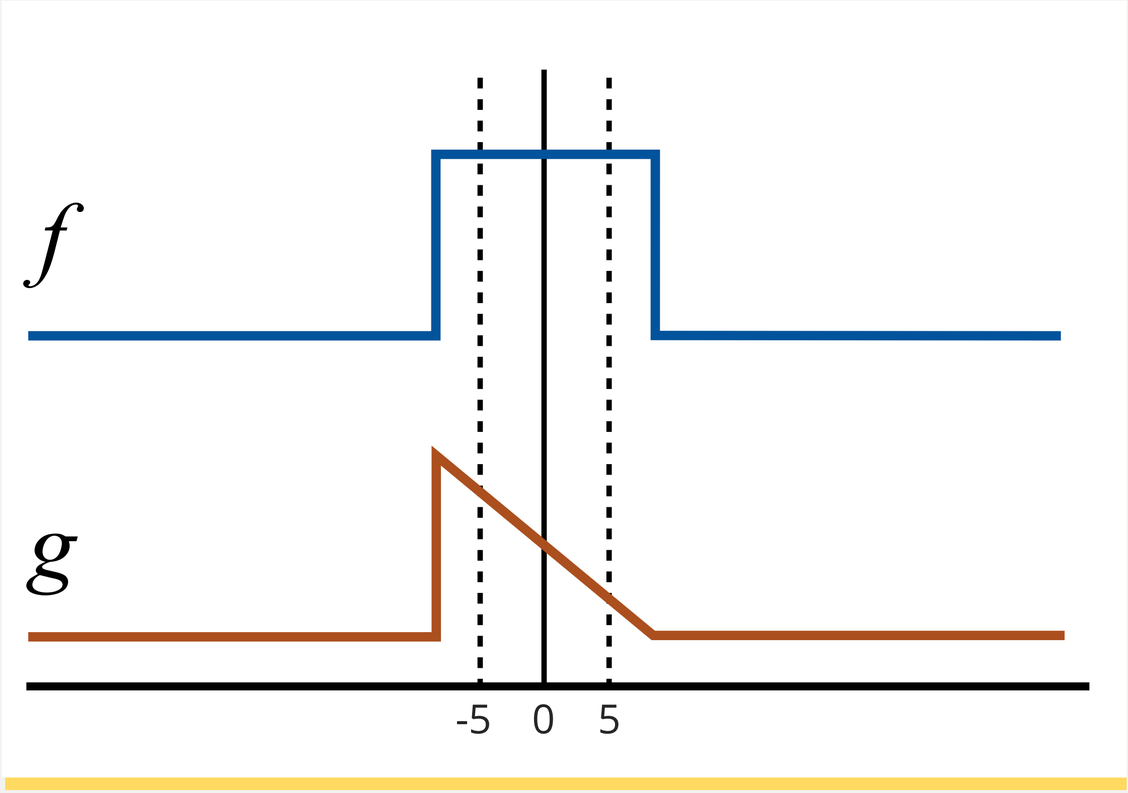
1D Spatial Convolution



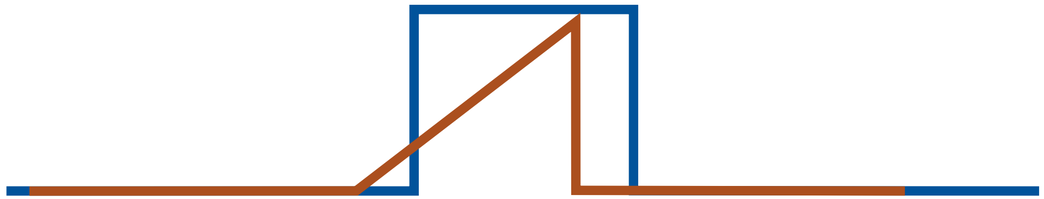
$$(f \times g)[-5] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(5+m)]$$



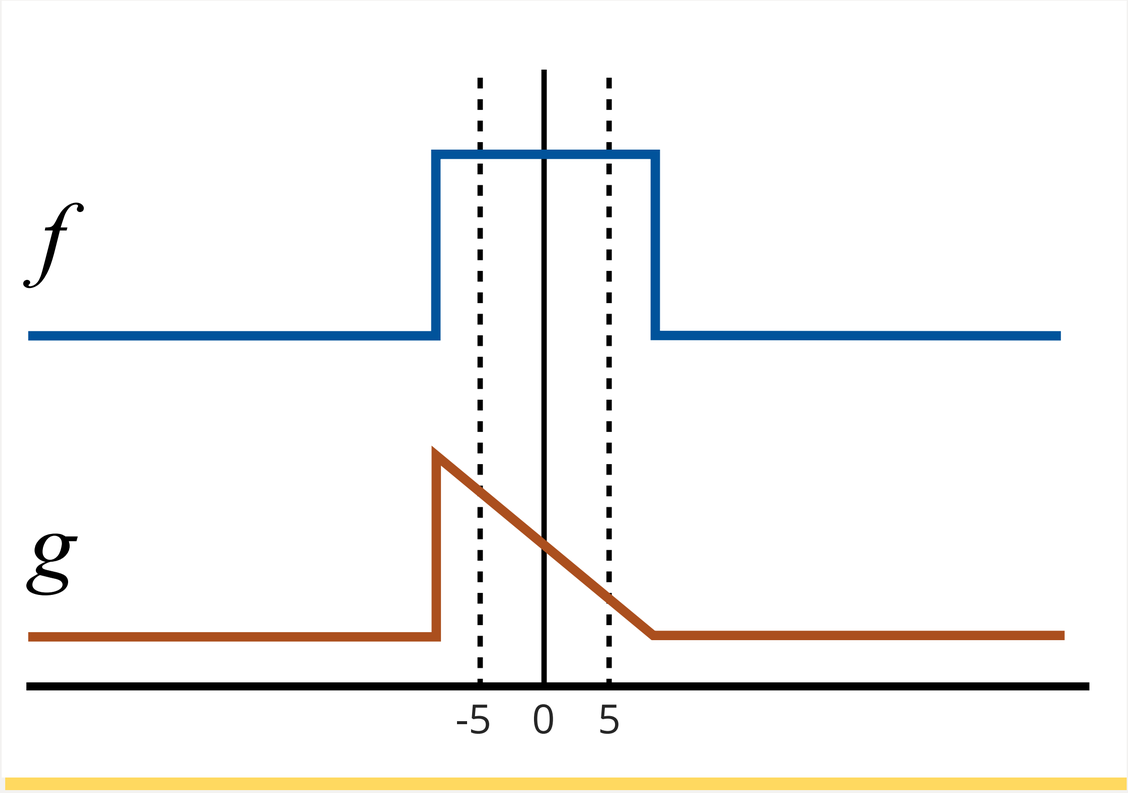
1D Spatial Convolution



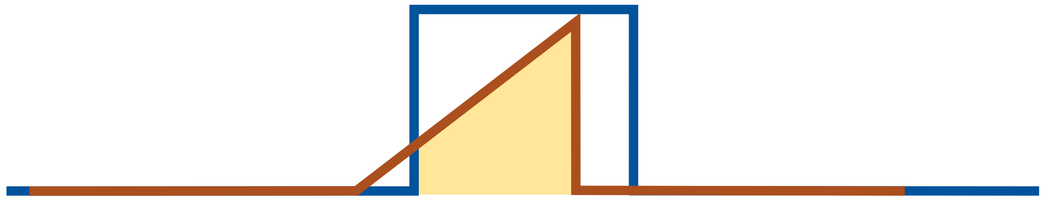
$$(f \times g)[-5] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(5+m)]$$



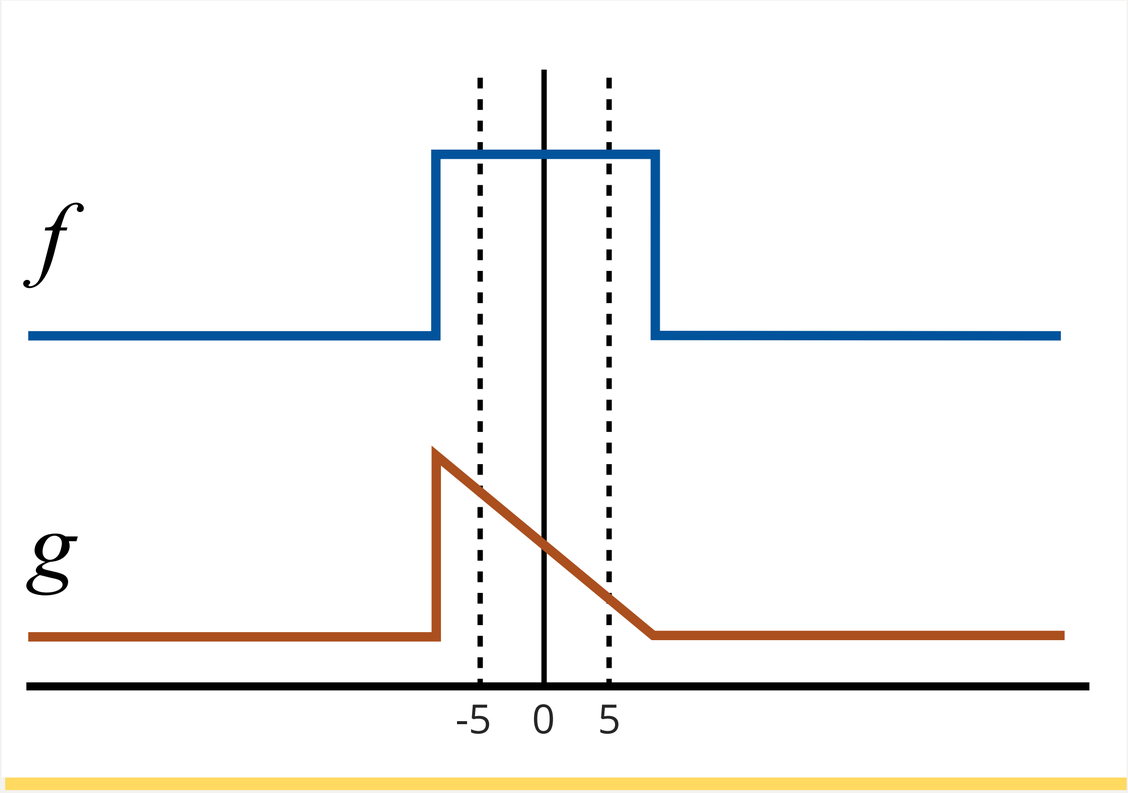
1D Spatial Convolution



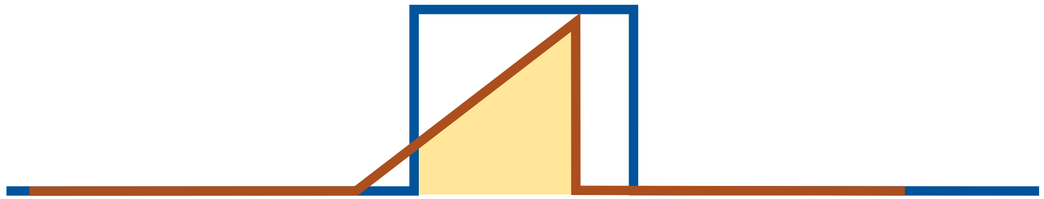
$$(f \times g)[-5] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(5+m)]$$



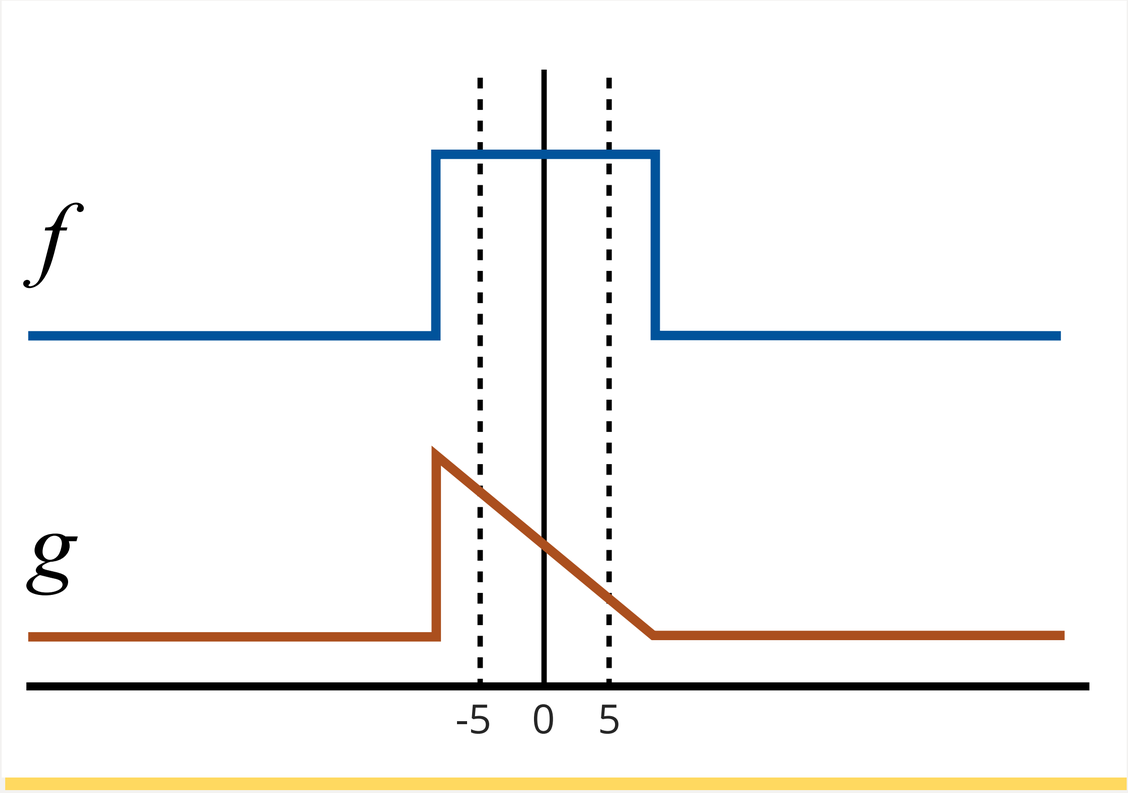
1D Spatial Convolution



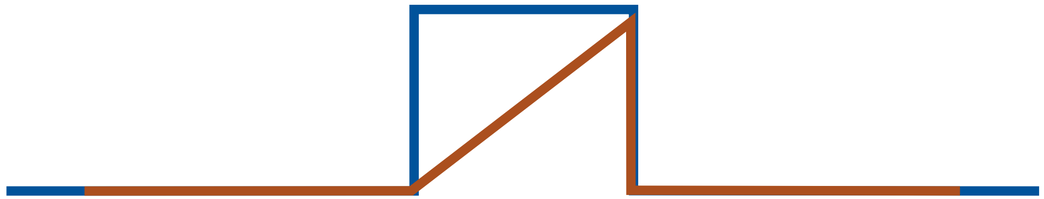
$$(f \times g)[-5] = \sum_{m=-\infty}^{\infty} f[m]\,g[-(5+m)] = 15$$



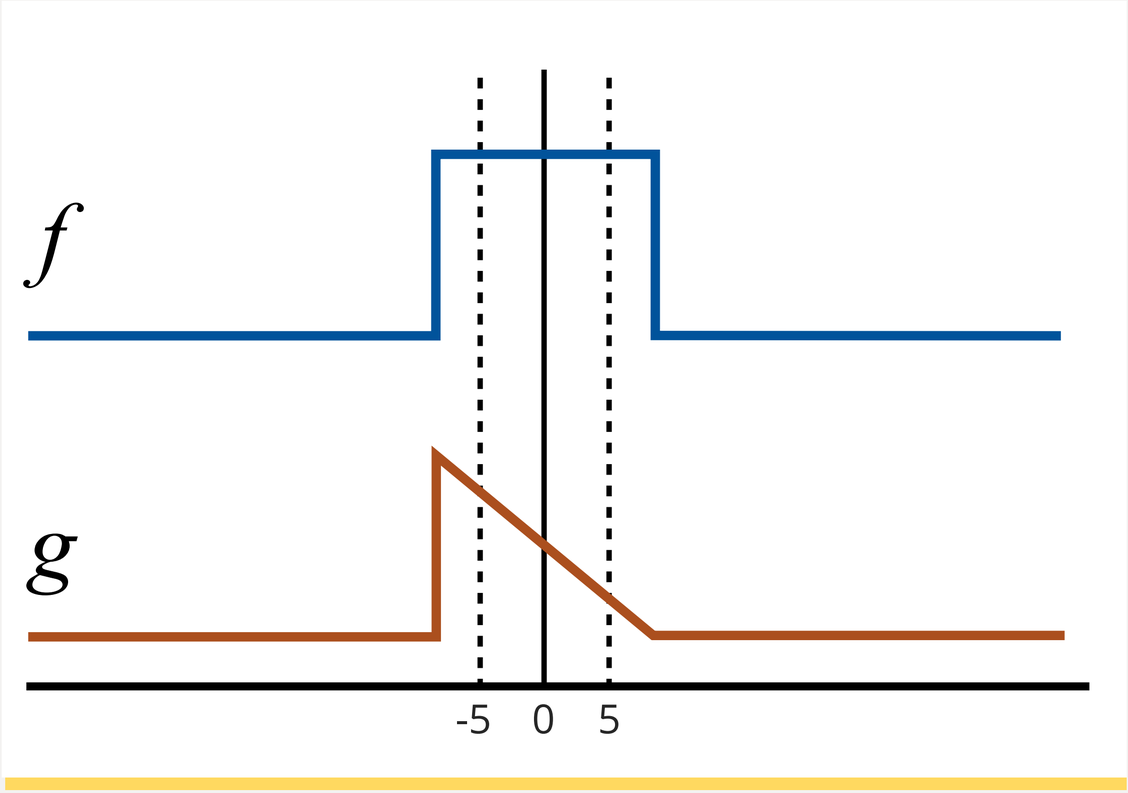
1D Spatial Convolution



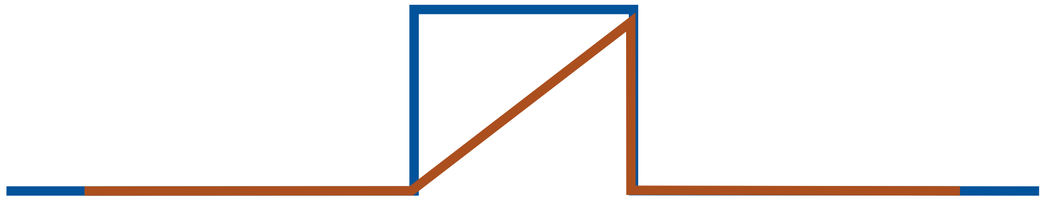
$$(f \times g)[-5] = \sum_{m=-\infty}^{\infty} f[m]\, g[(-m)]$$



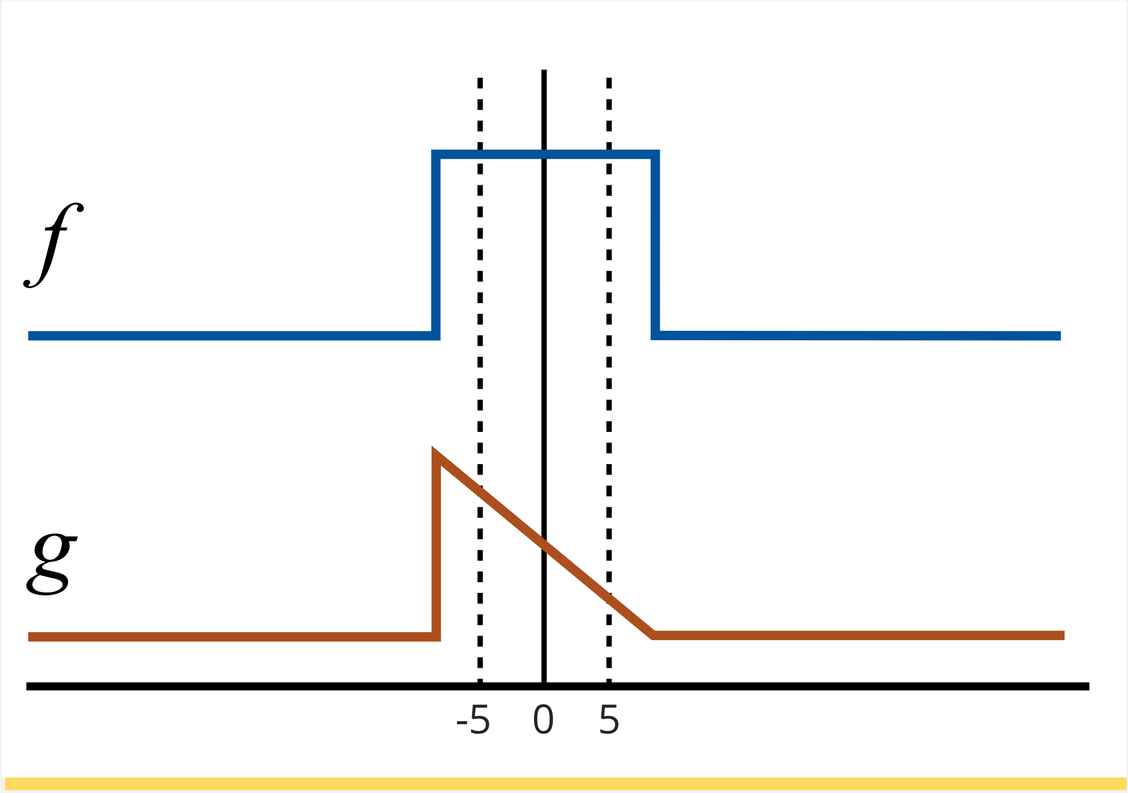
1D Spatial Convolution



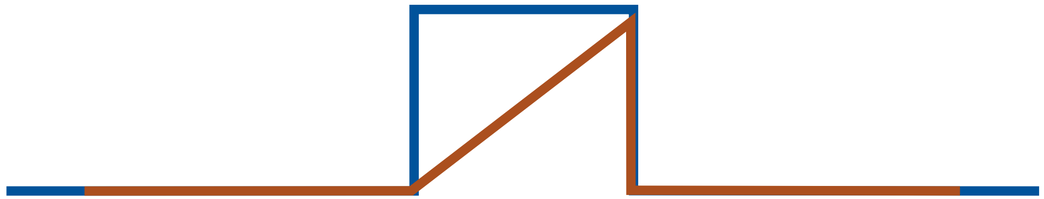
$$(f \times g)[n] = \sum_{m=-\infty}^{\infty} f[m]\, g[(-m)]$$



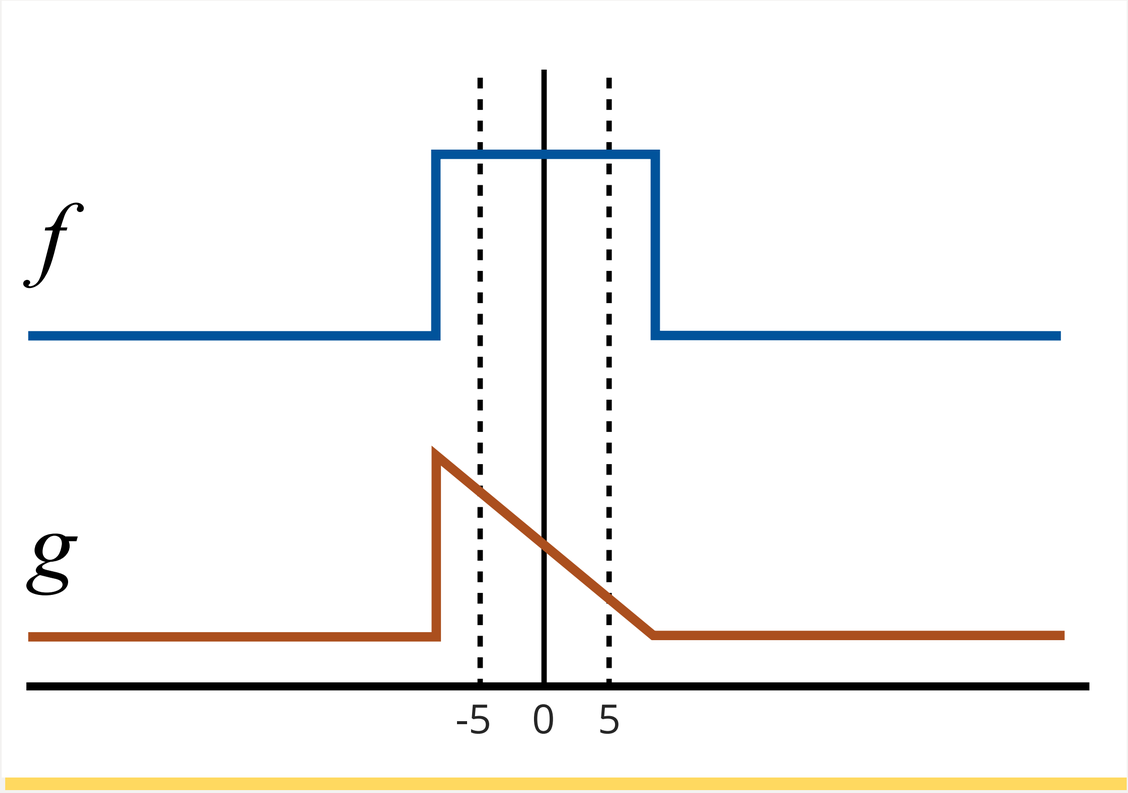
1D Spatial Convolution



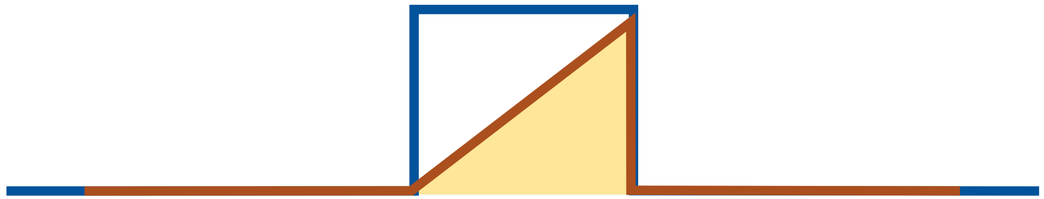
$$(f \times g)[0] = \sum_{m=-\infty}^{\infty} f[m]\,g[(-m)]$$



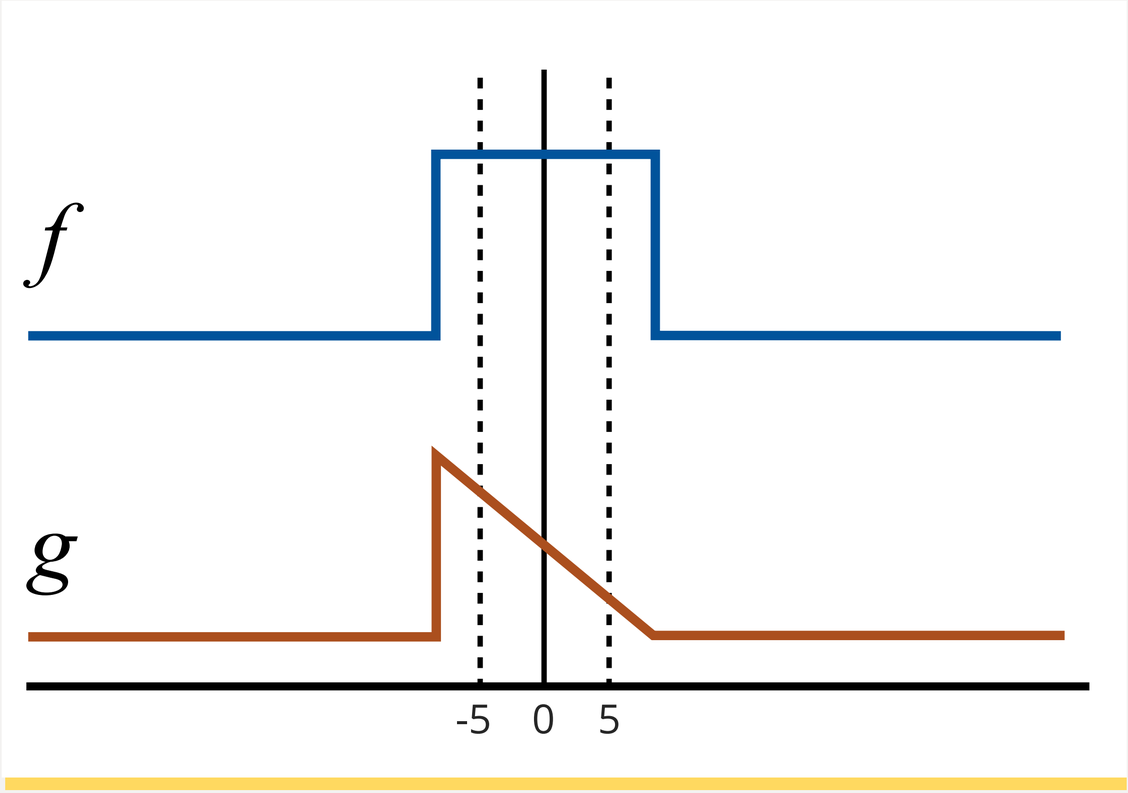
1D Spatial Convolution



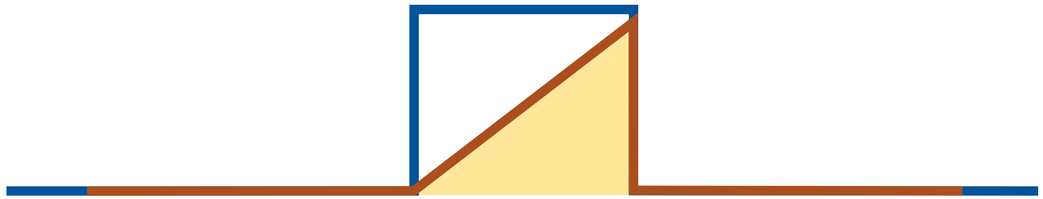
$$(f \times g)[0] = \sum_{m=-\infty}^{\infty} f[m]\,g[(-m)] = 20$$



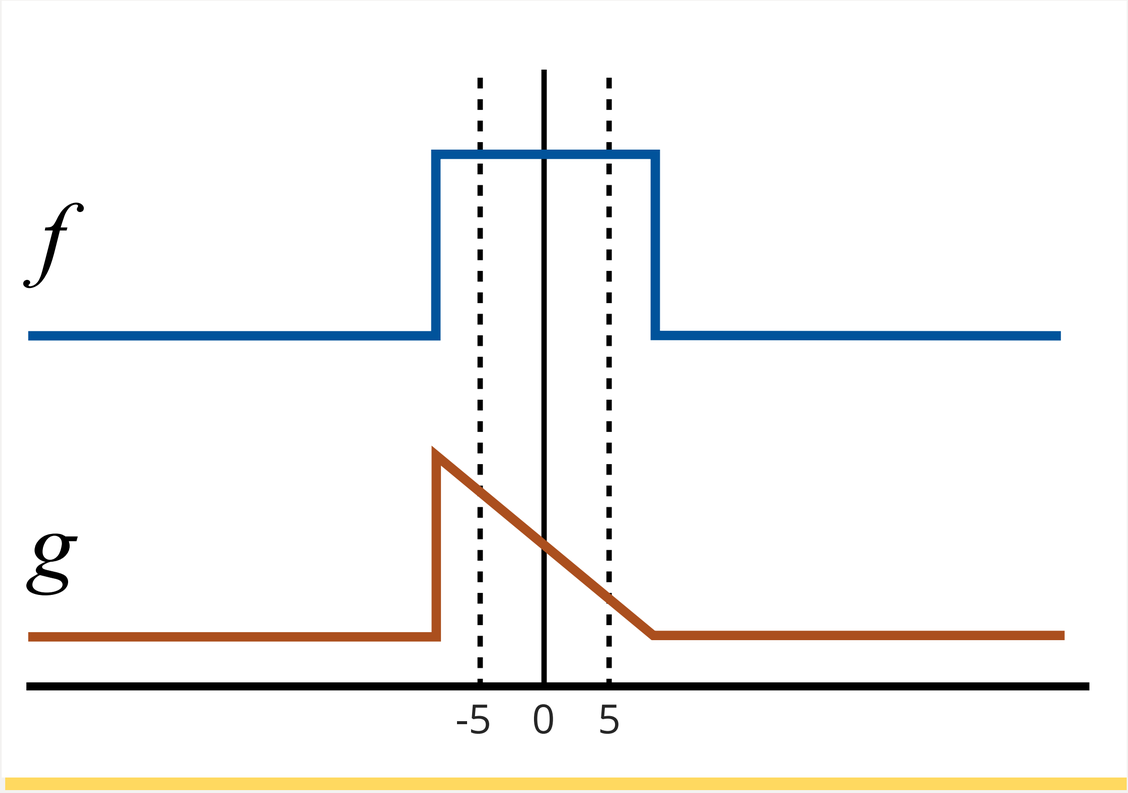
1D Spatial Convolution



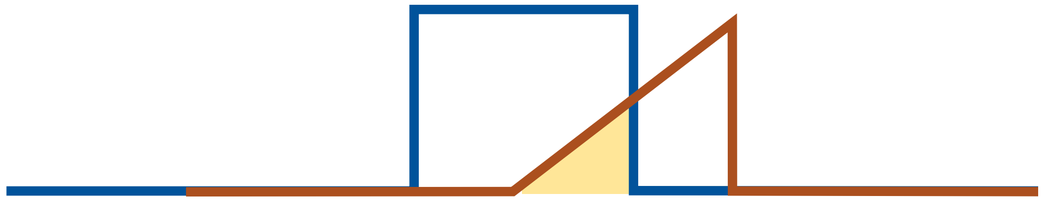
$$(f \times g)[0] = \sum_{m=-\infty}^{\infty} f[m]\,g[(-m)]$$



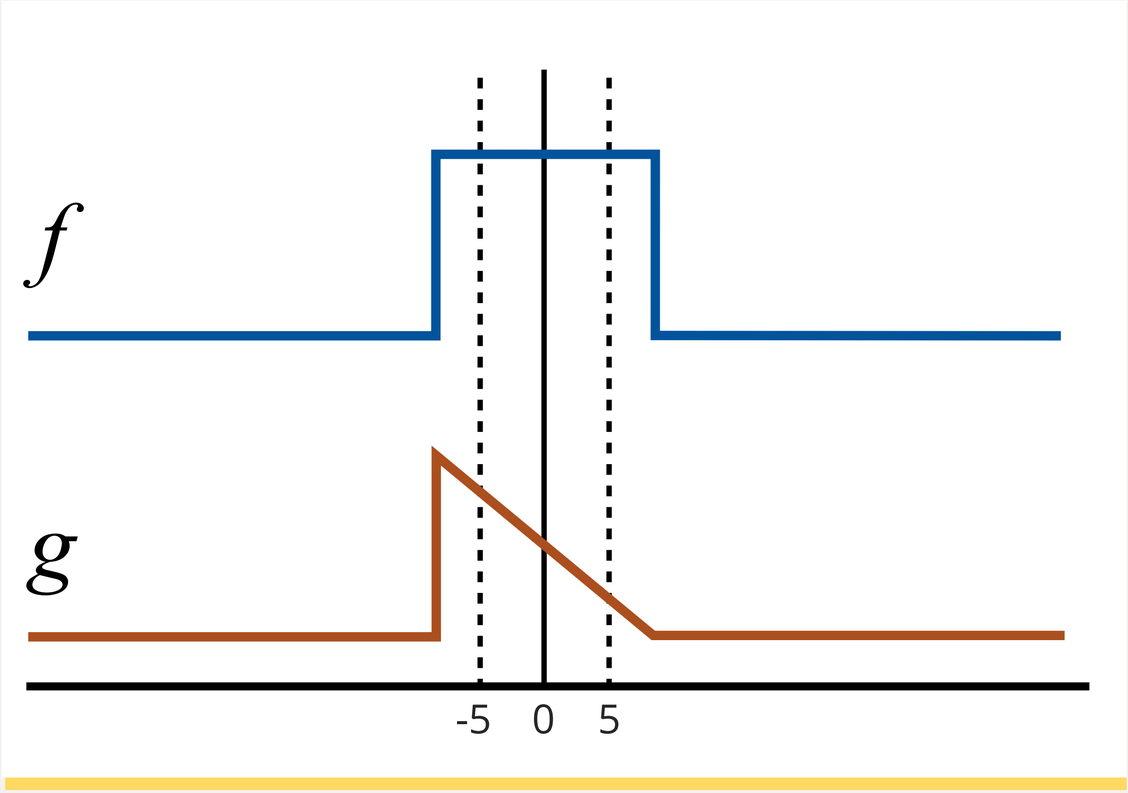
1D Spatial Convolution



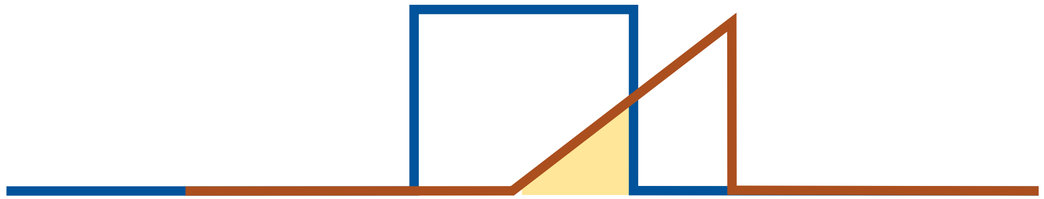
$$(f \times g)[10] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(-10+m)] = 10$$



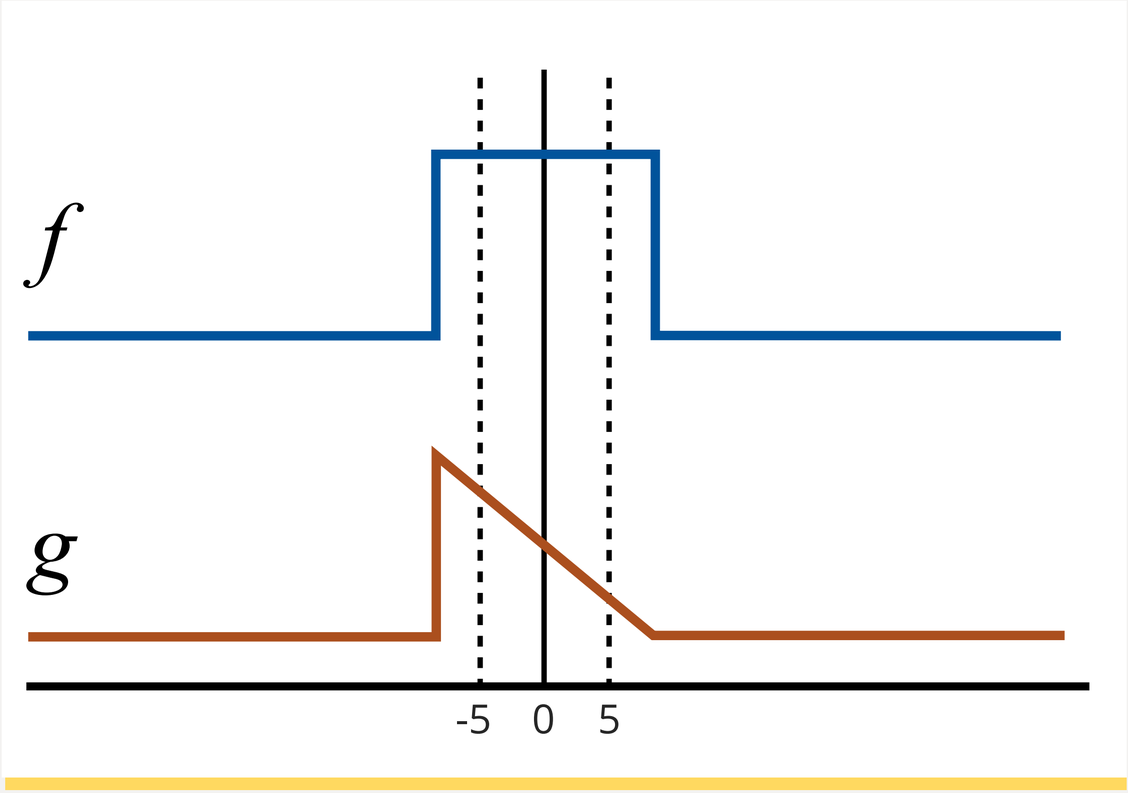
1D Spatial Convolution



$$(f \times g)[10] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(-10+m)] = 10$$

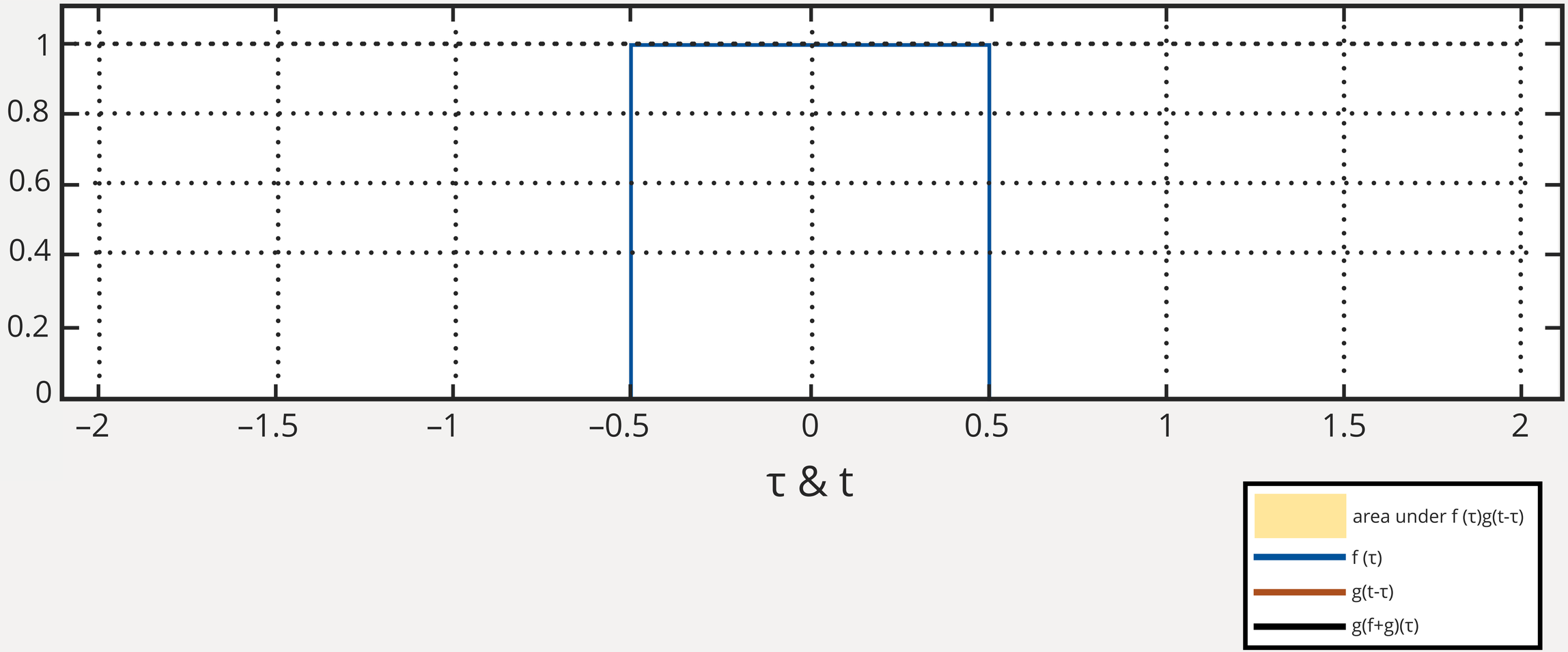


1D Spatial Convolution

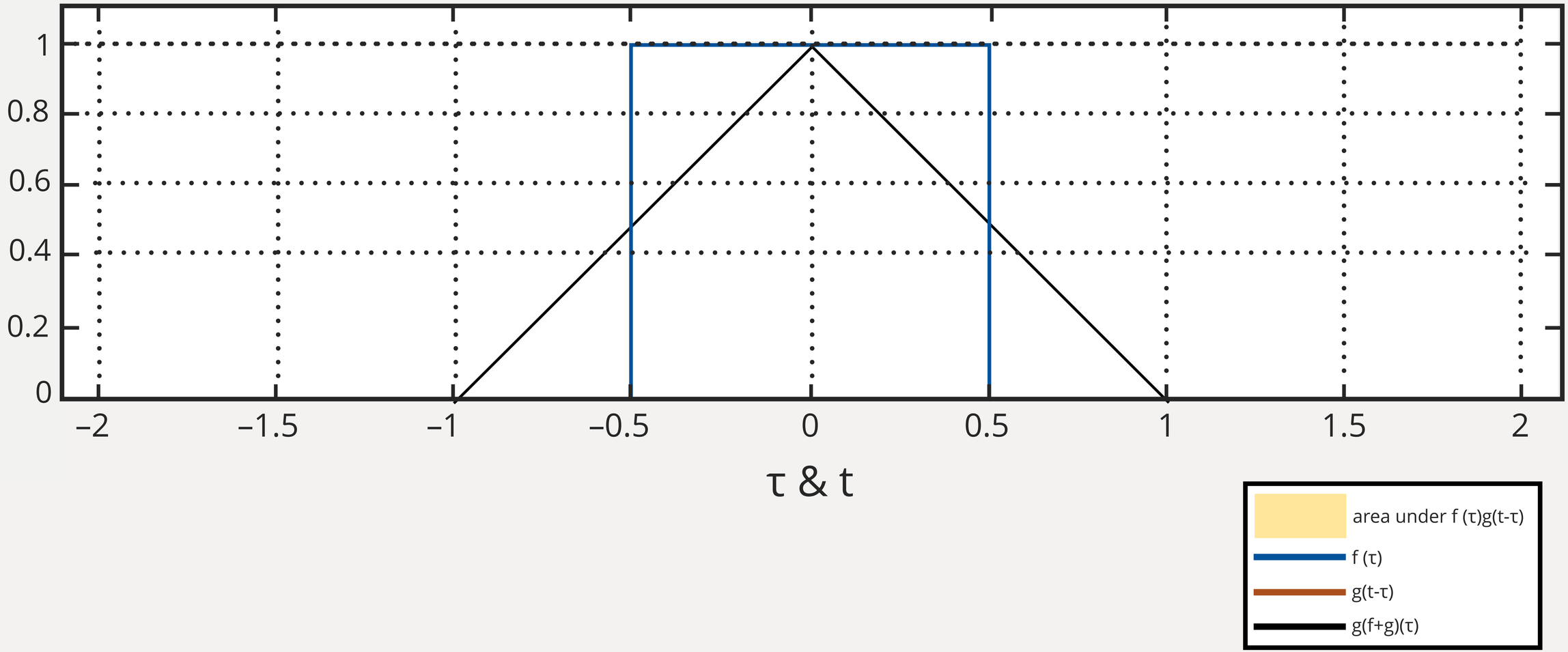


$$(f \times g)[20] = \sum_{m=-\infty}^{\infty} f[m]\, g[-(-20+m)] = 0$$

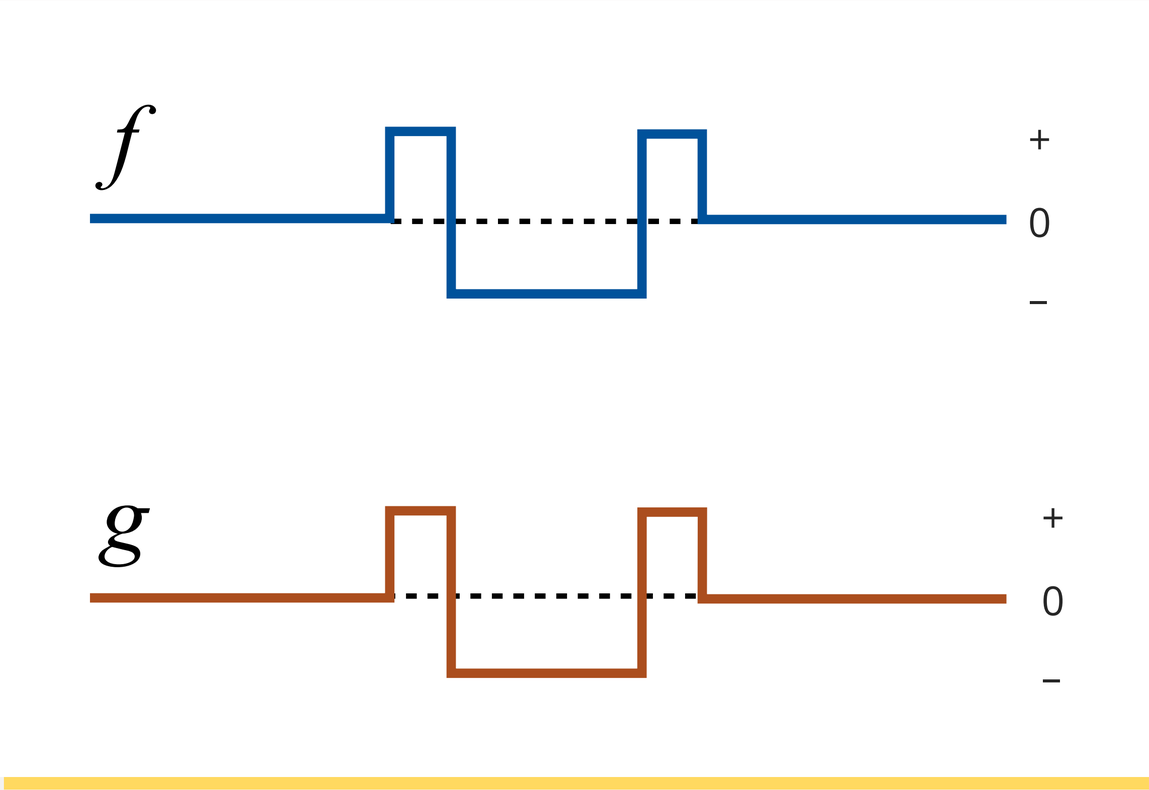
1D Spatial Convolution



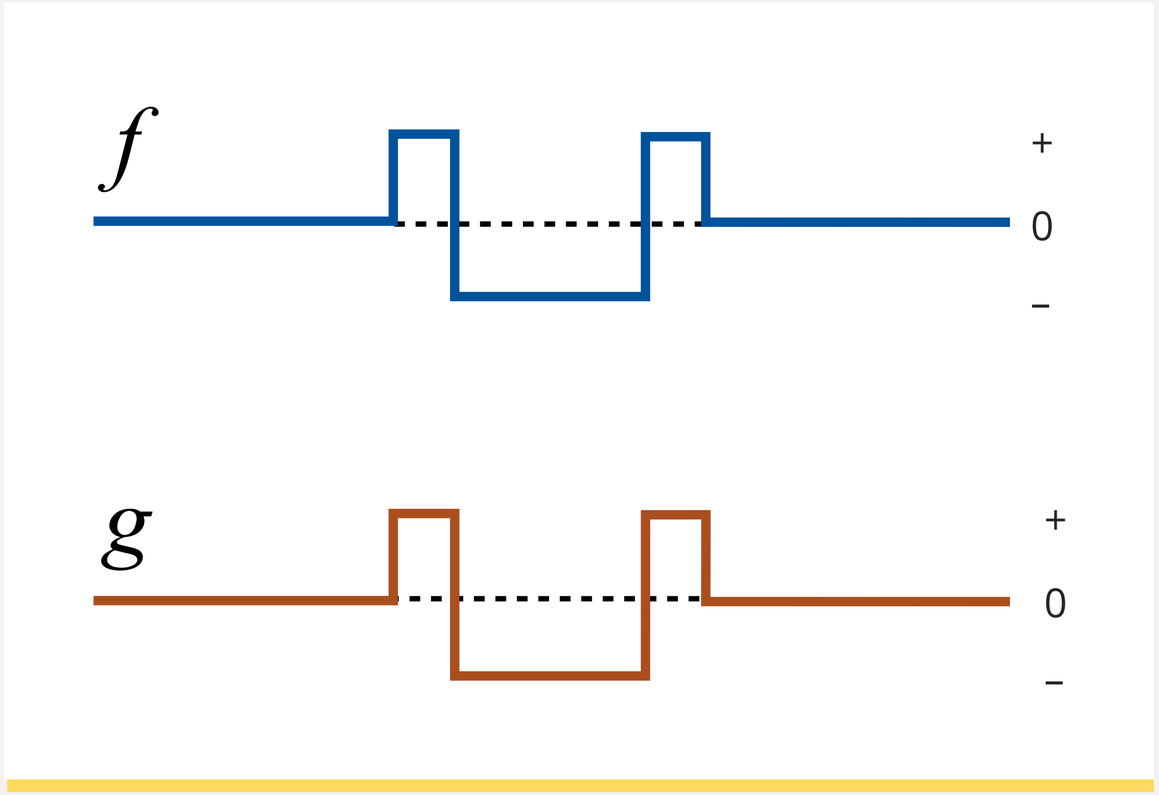
1D Spatial Convolution

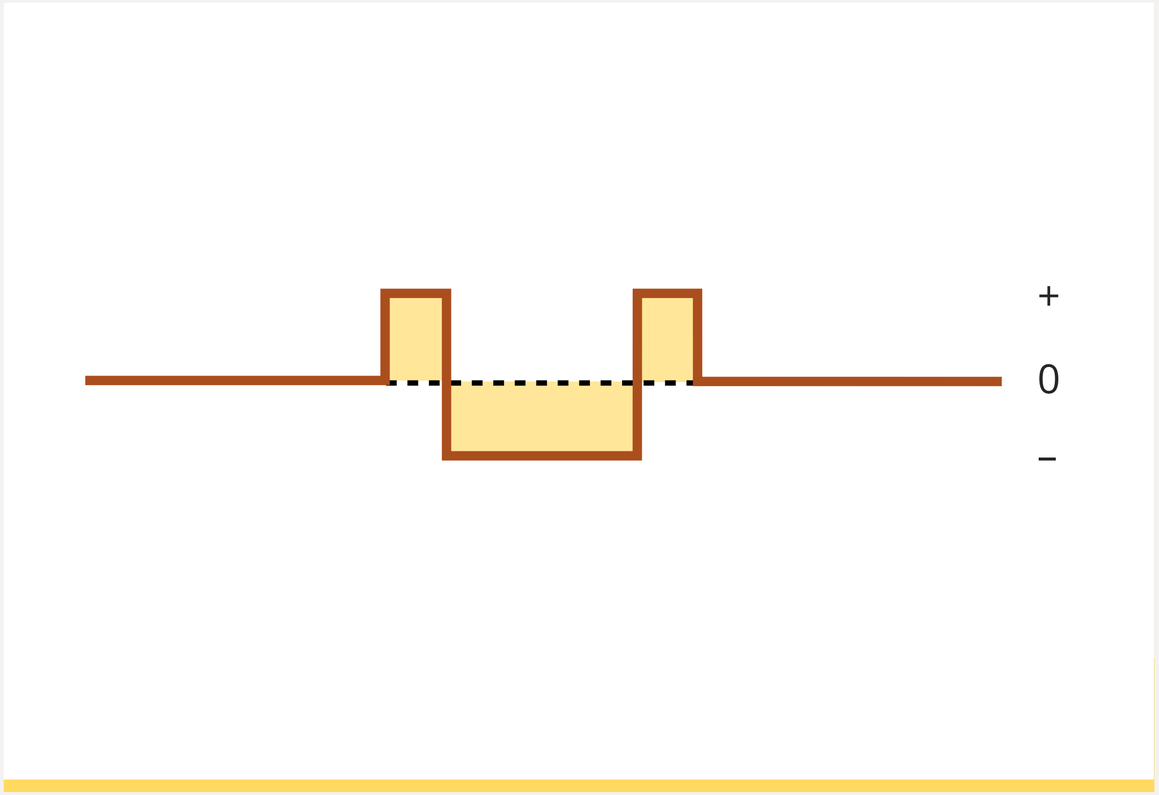


Convolution Filters are Feature Detectors

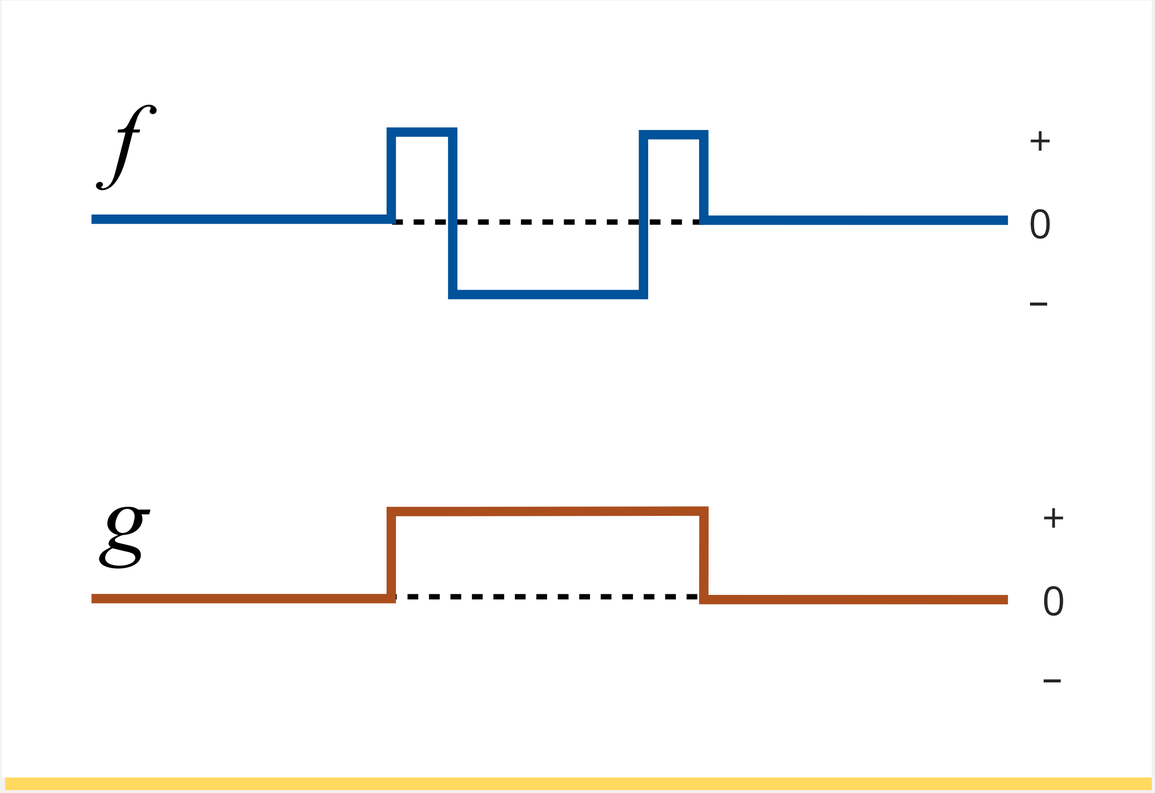


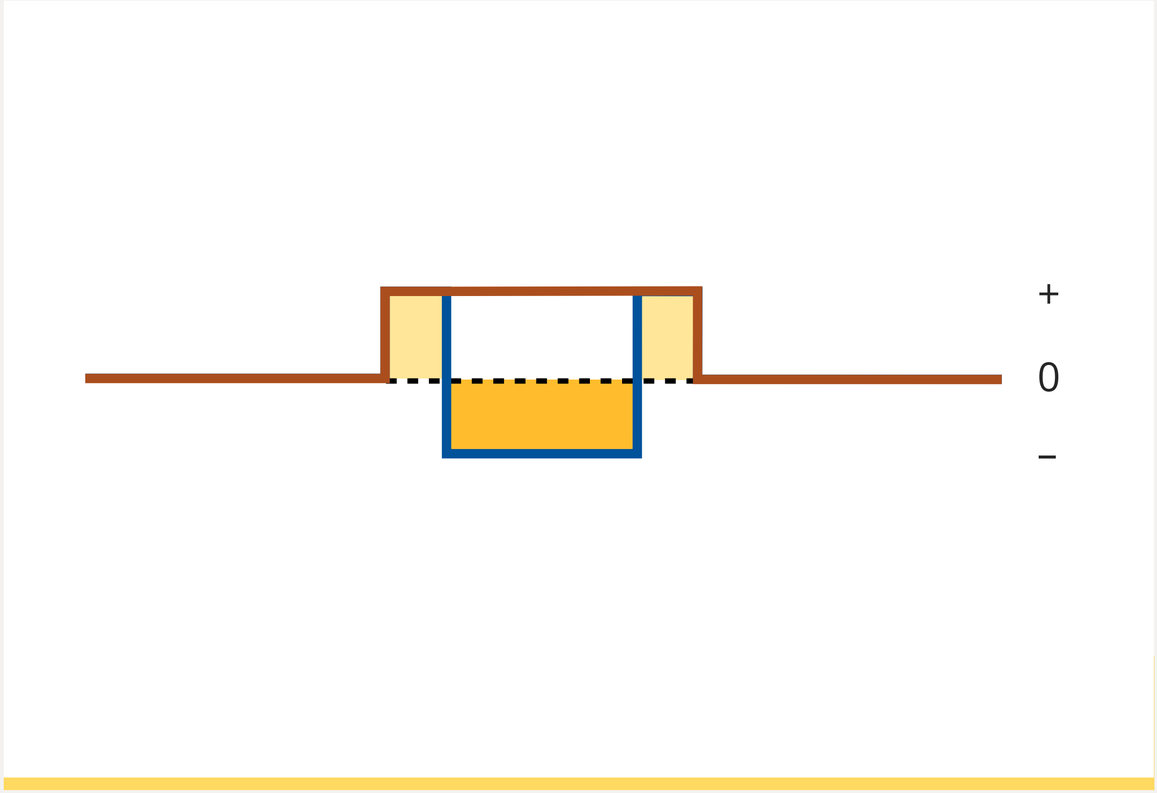
Convolution Filters are Feature Detectors



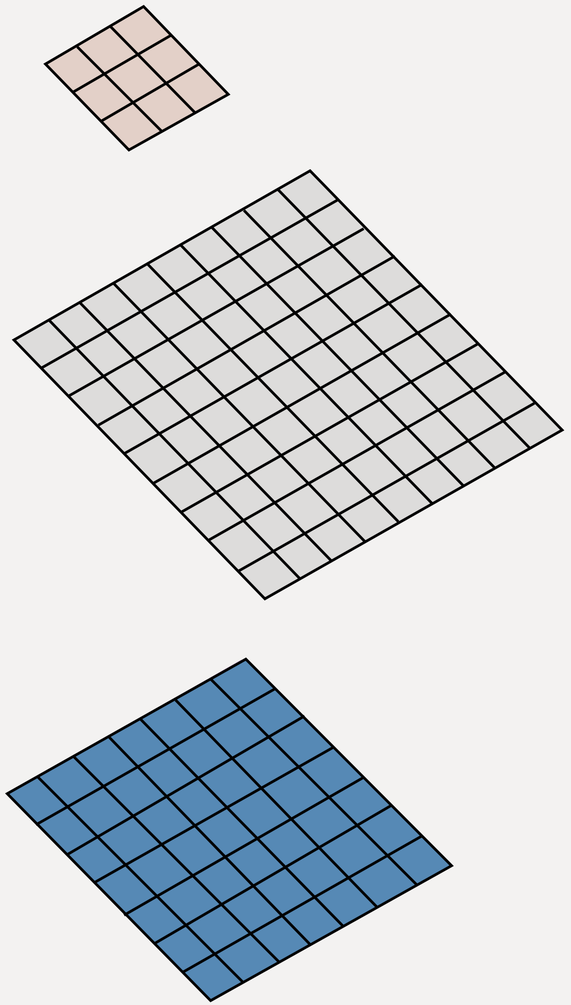


Convolution Filters are Feature Detectors



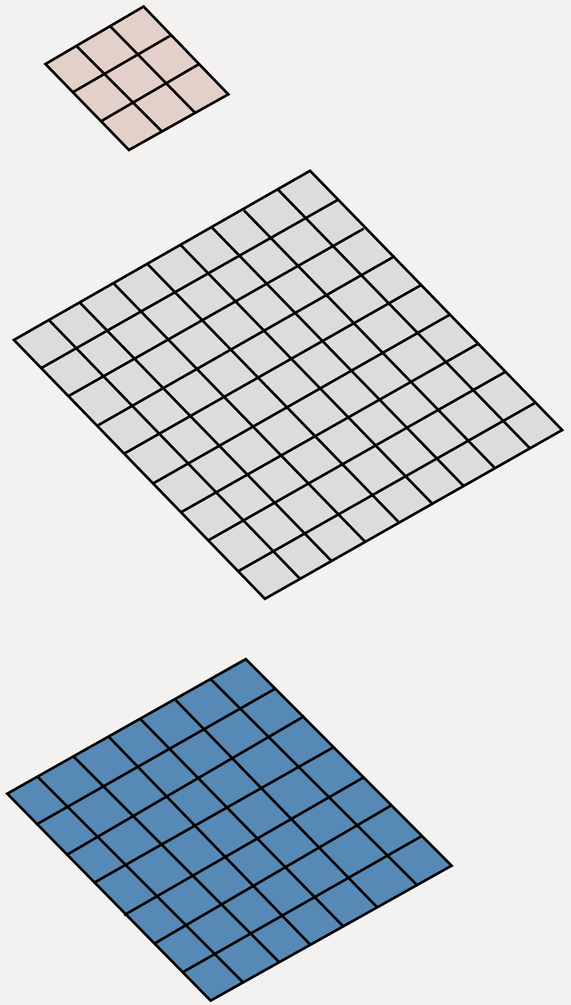


2D Spatial Convolution

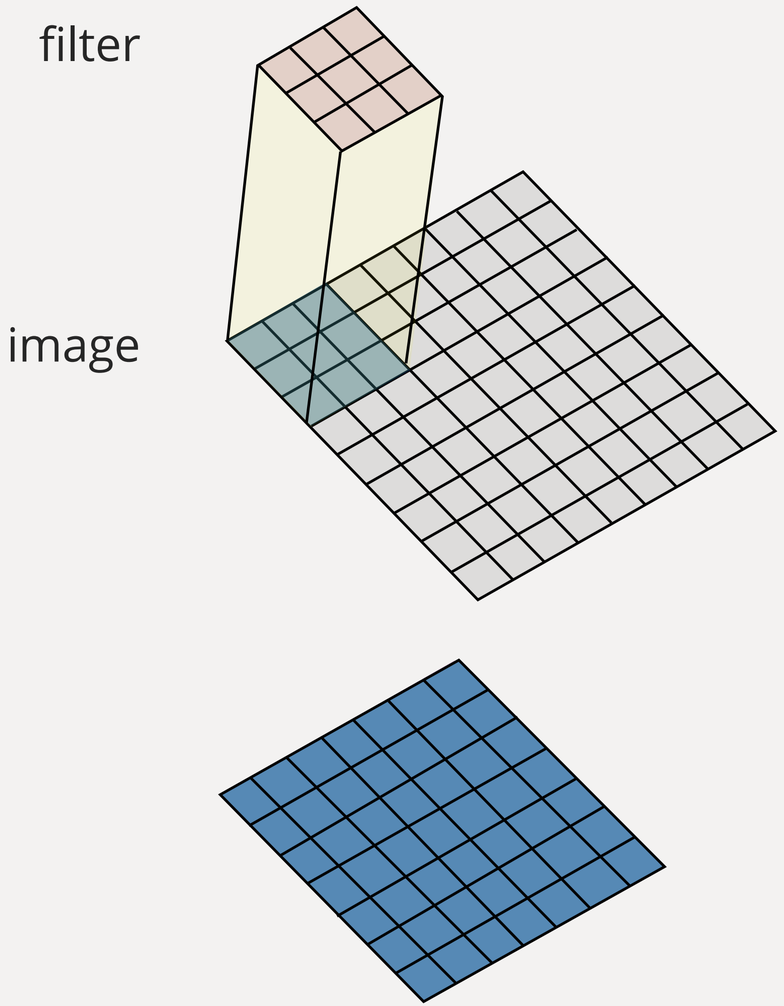


2D Spatial Convolution

filter



2D Spatial Convolution

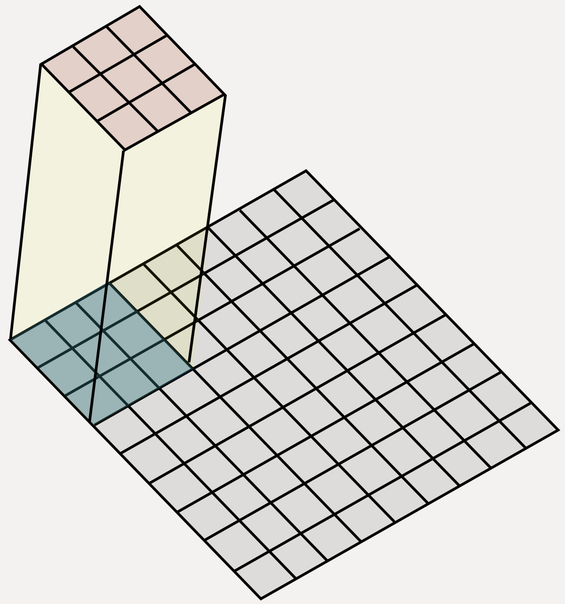


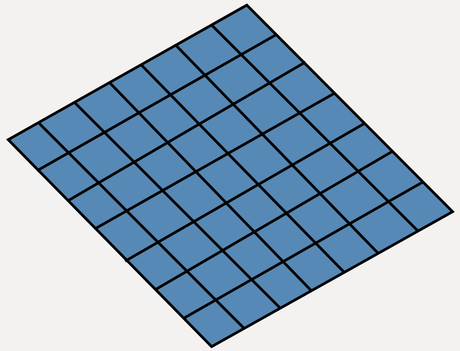
2D Spatial Convolution

filter

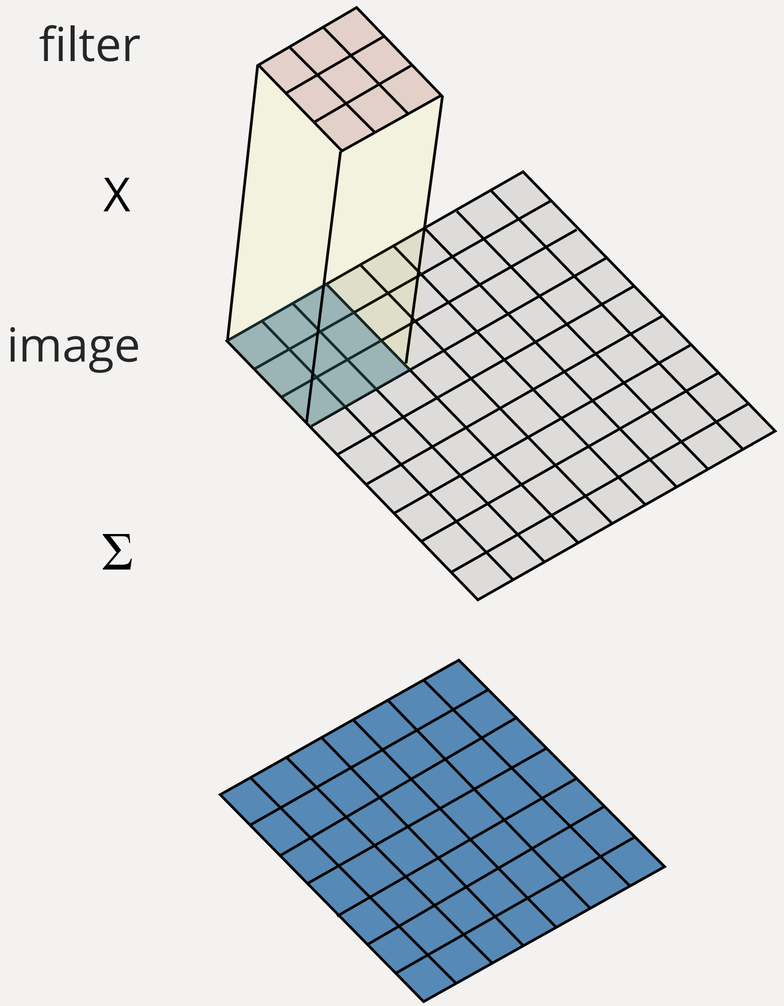
X

image

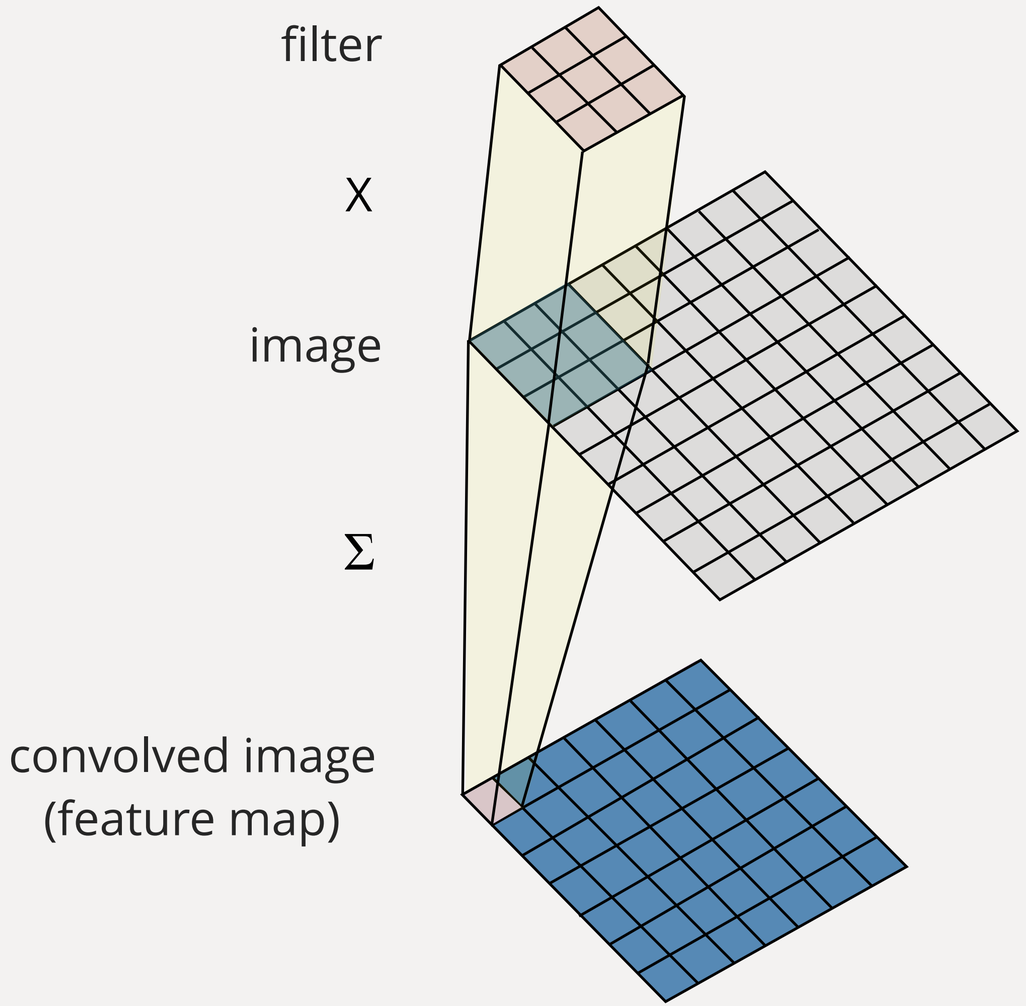




2D Spatial Convolution



2D Spatial Convolution



2D Spatial Convolution

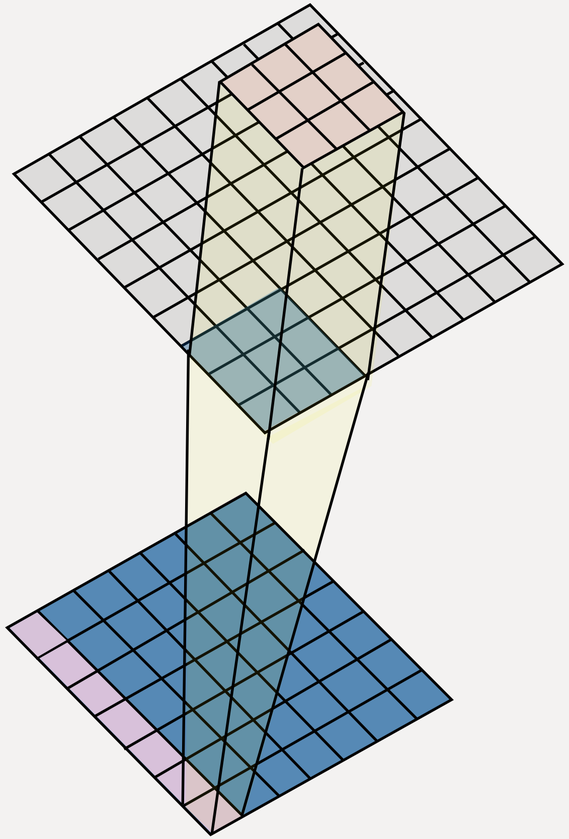
filter

X

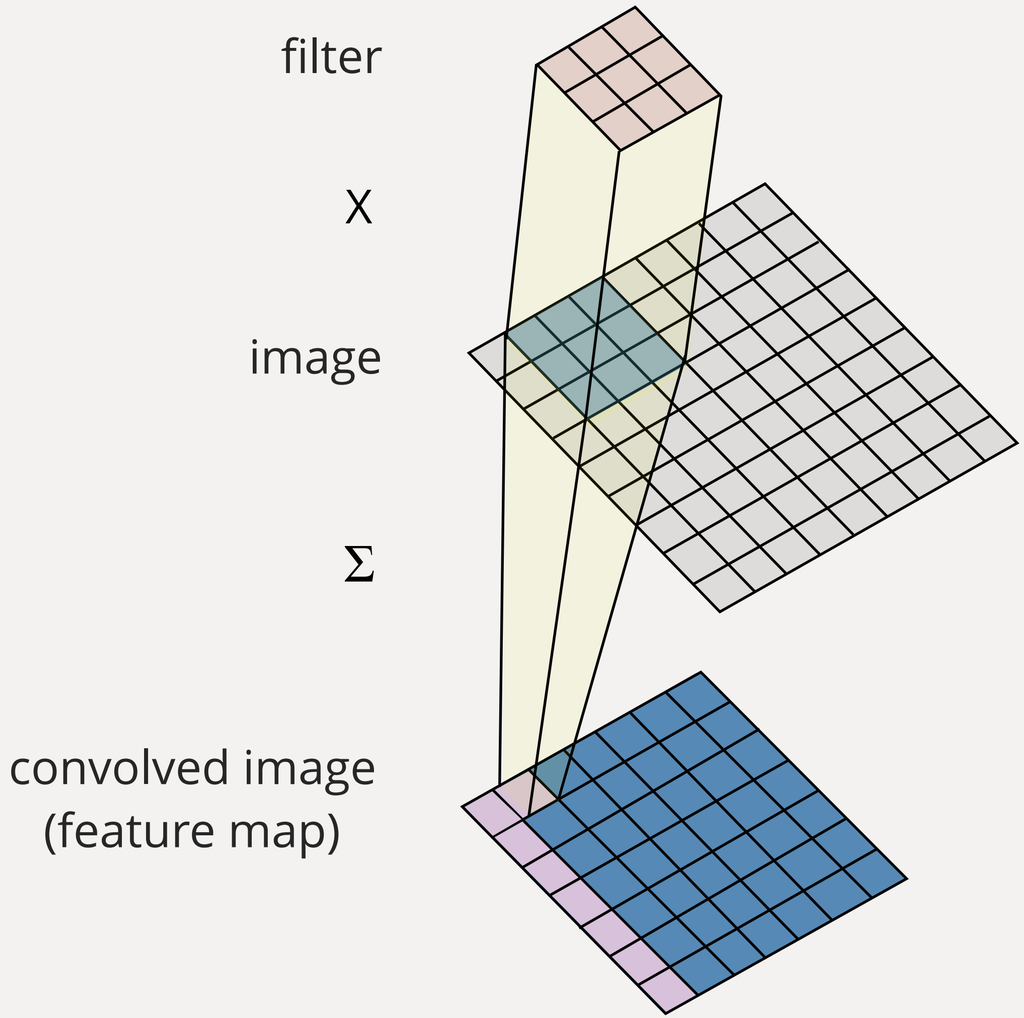
image

Σ

convolved image
(feature map)



2D Spatial Convolution



2D Spatial Convolution

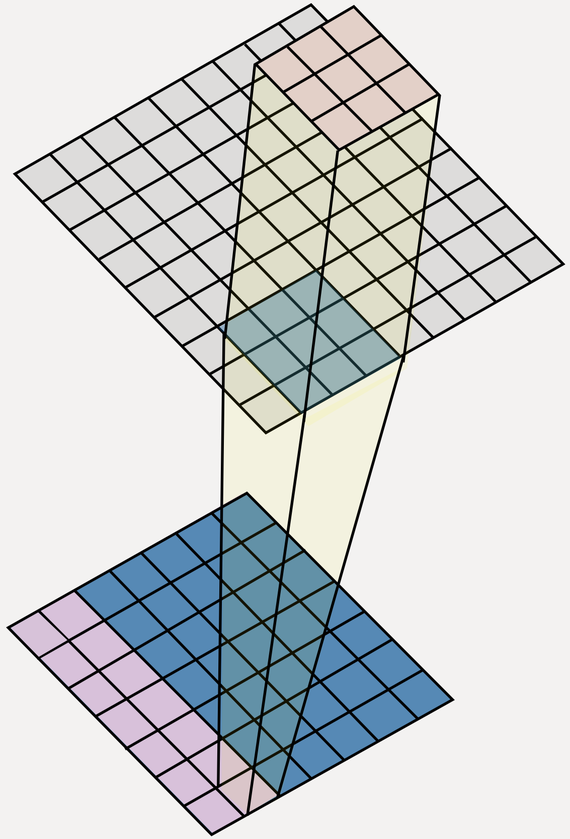
filter

X

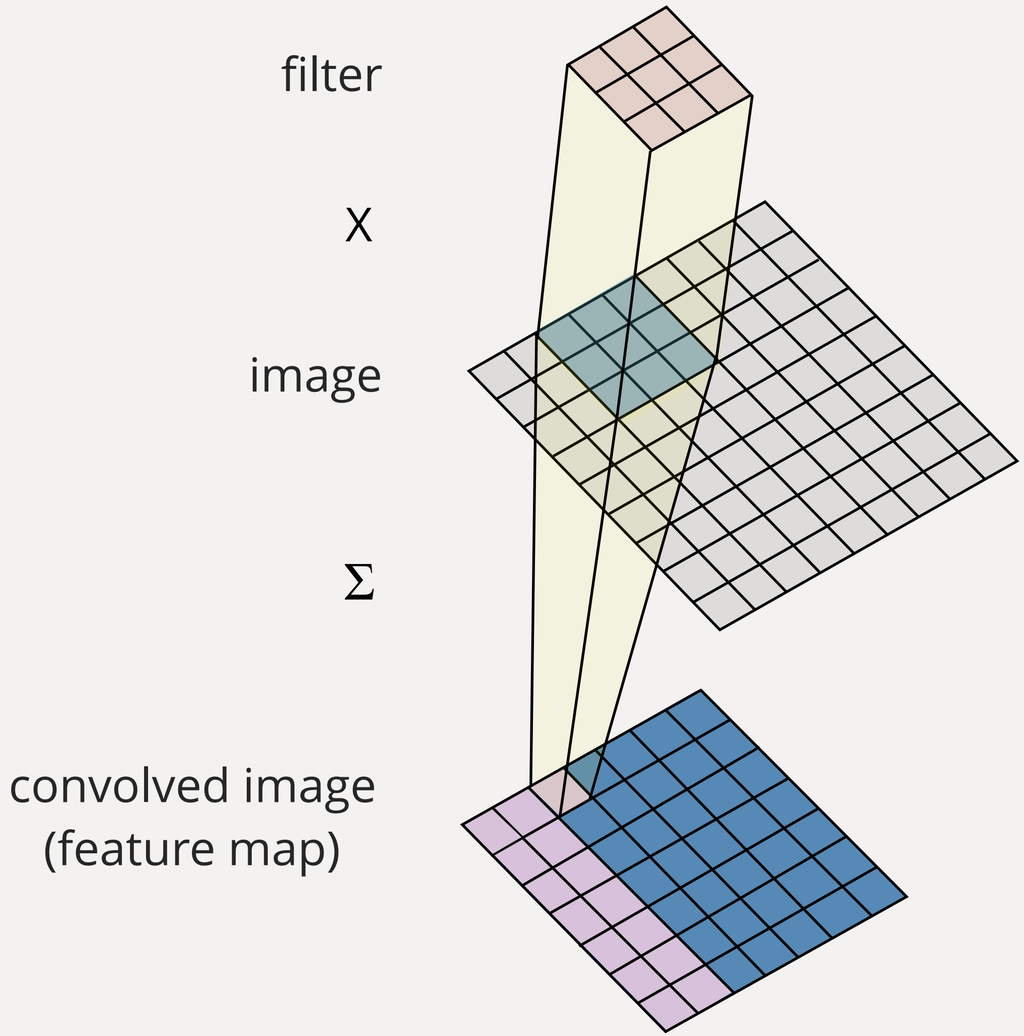
image

Σ

convolved image
(feature map)



2D Spatial Convolution



2D Spatial Convolution

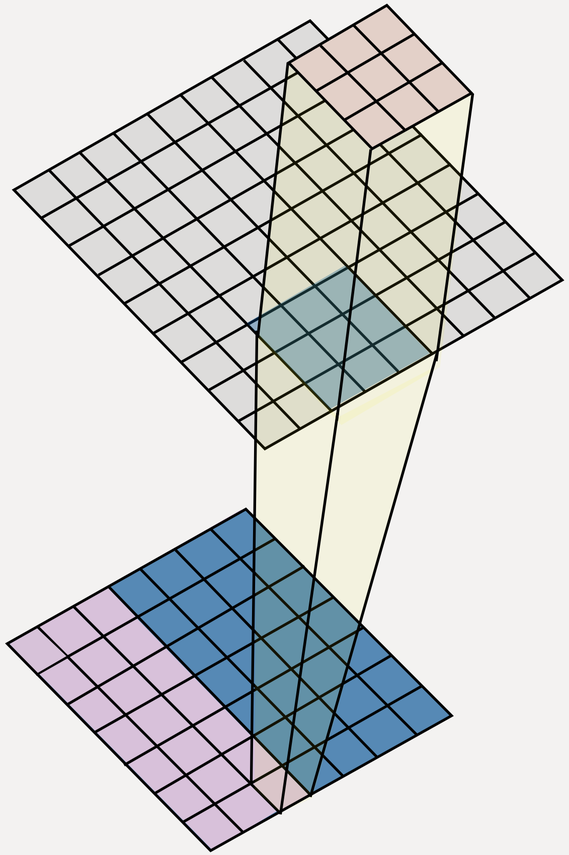
filter

X

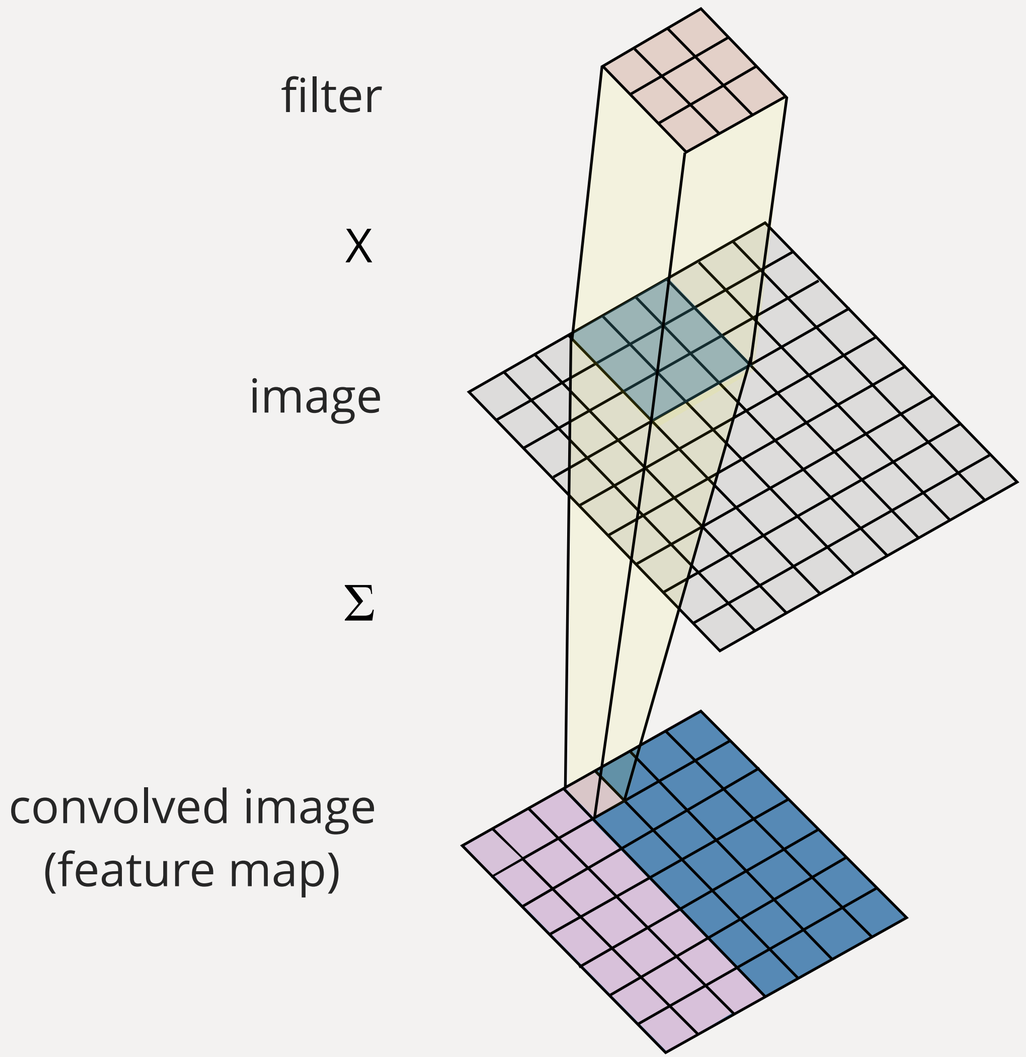
image

Σ

convolved image
(feature map)



2D Spatial Convolution



2D Spatial Convolution

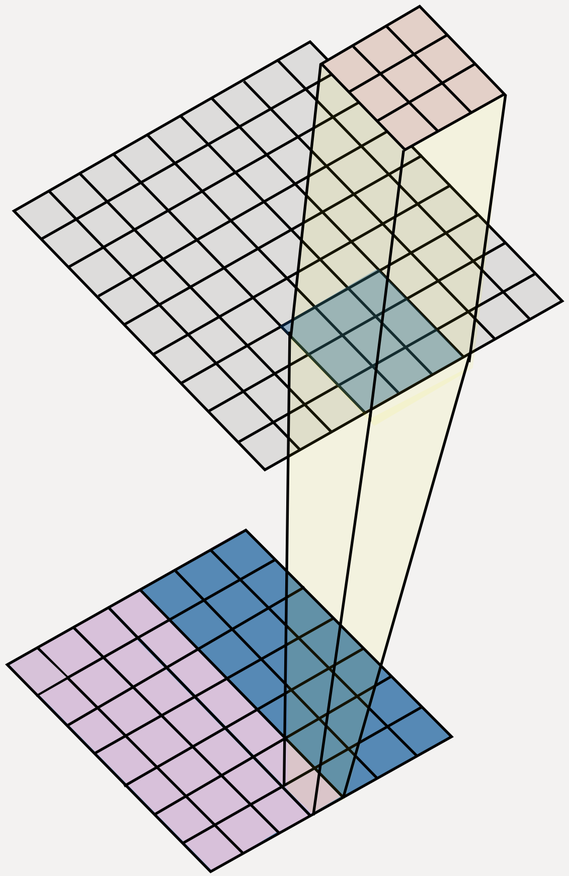
filter

X

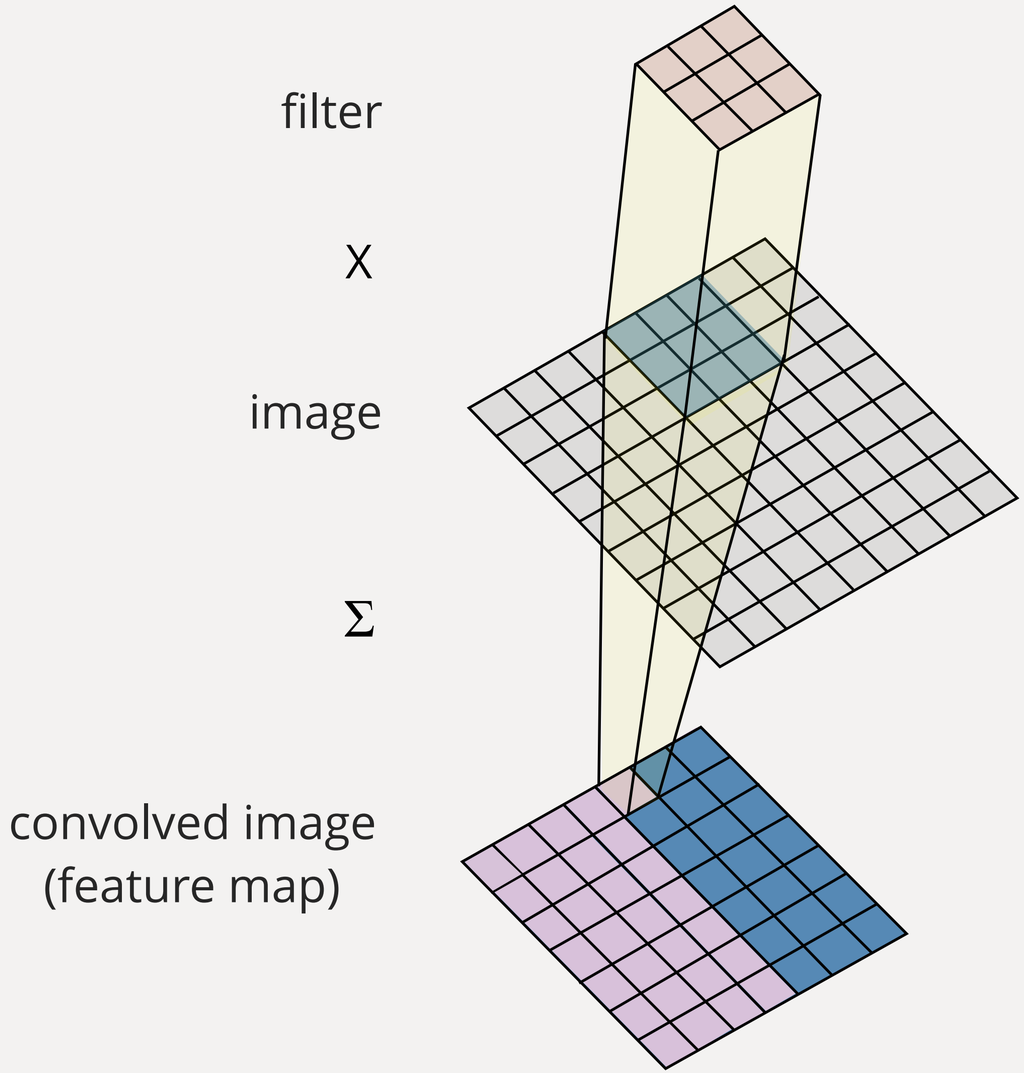
image

Σ

convolved image
(feature map)



2D Spatial Convolution



2D Spatial Convolution

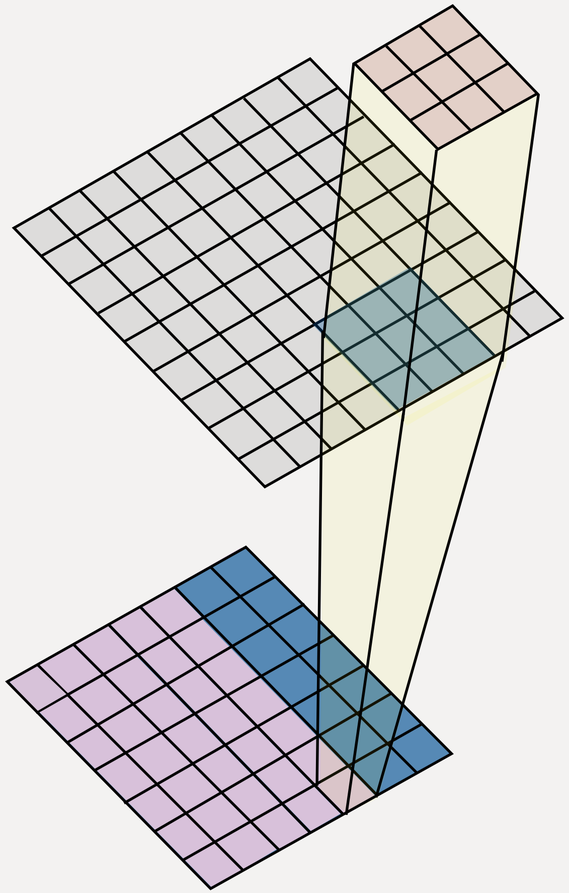
filter

X

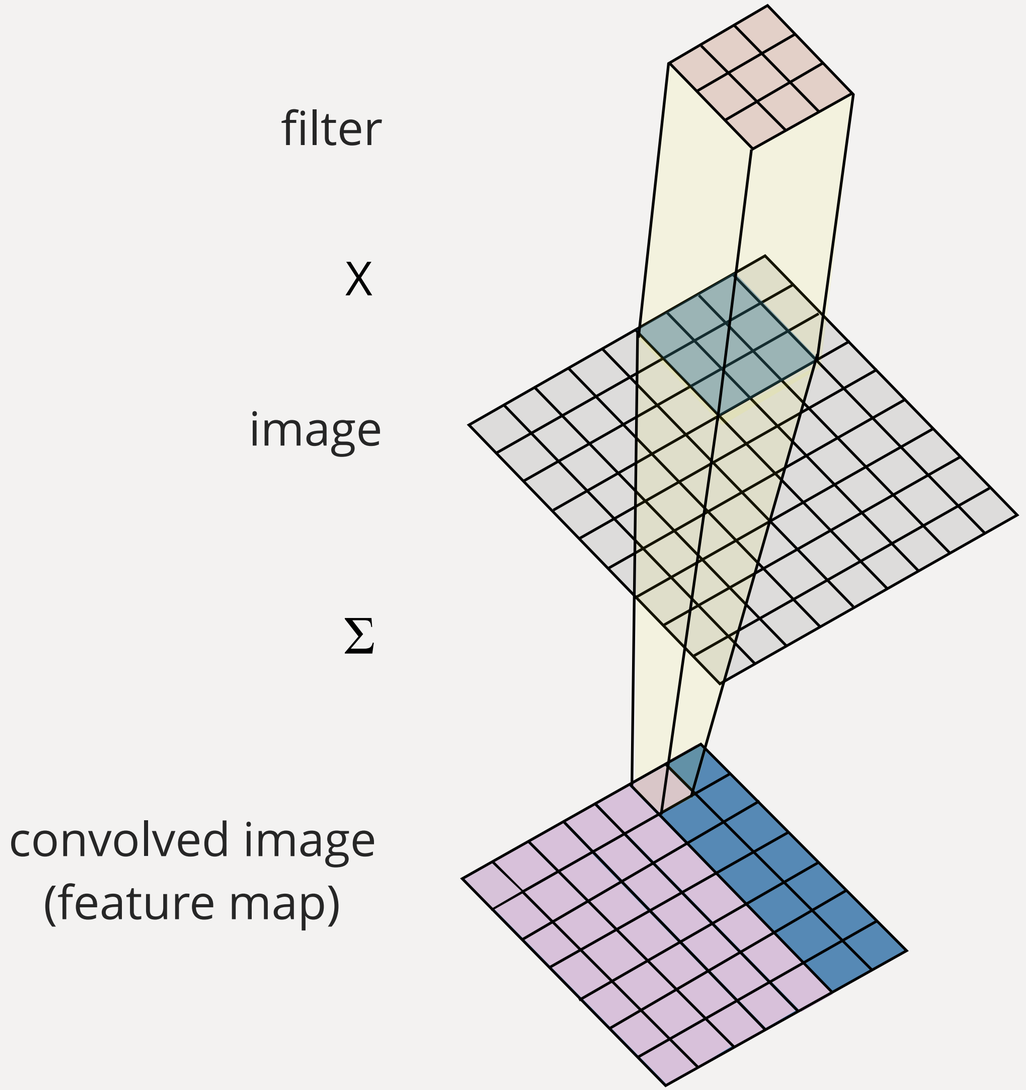
image

Σ

convolved image
(feature map)



2D Spatial Convolution



2D Spatial Convolution

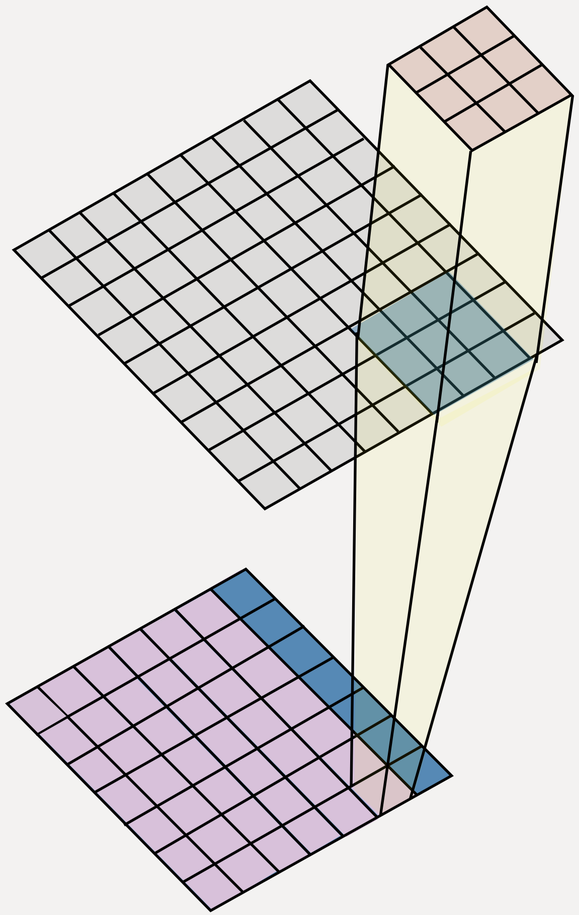
filter

X

image

Σ

convolved image
(feature map)



2D Spatial Convolution

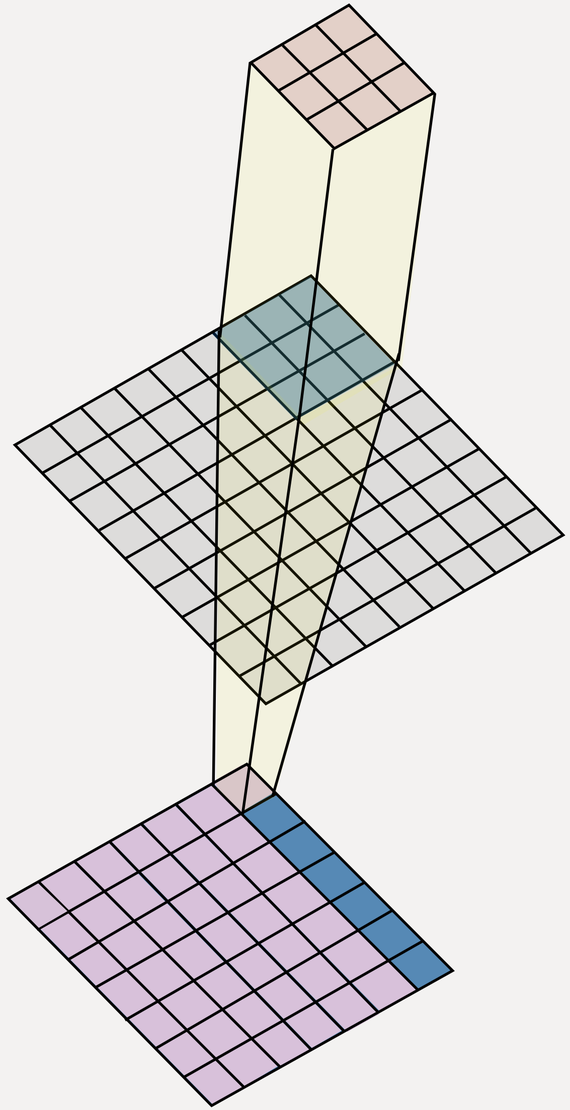
filter

X

image

Σ

convolved image
(feature map)



2D Spatial Convolution

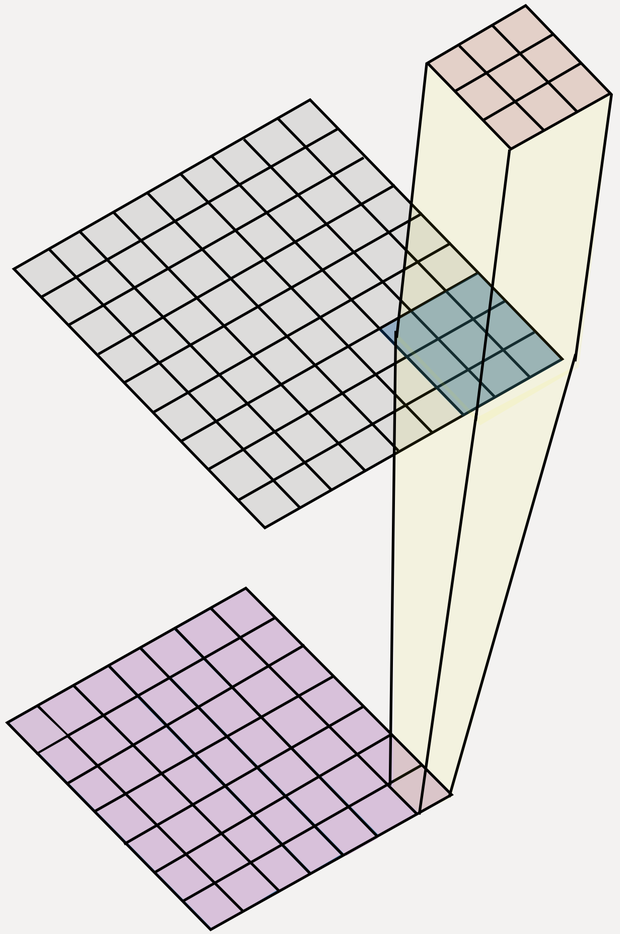
filter

X

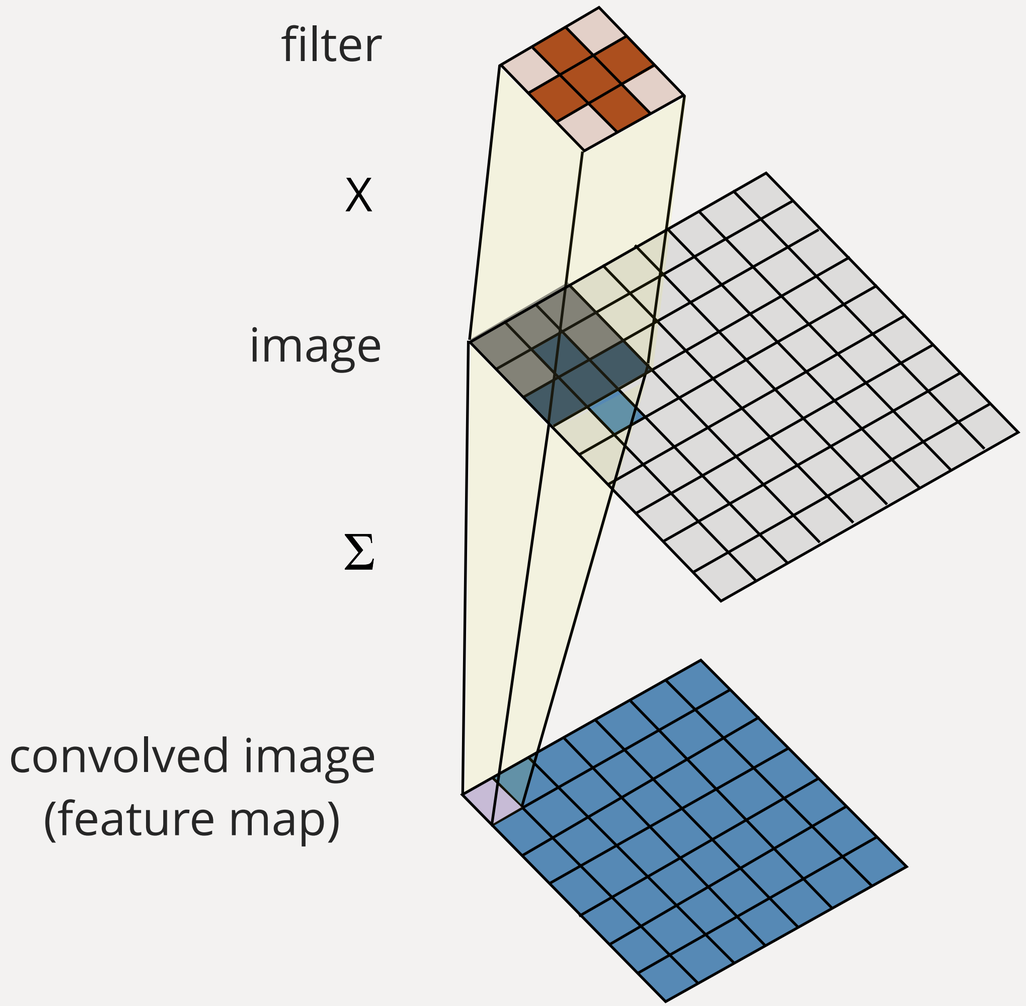
image

Σ

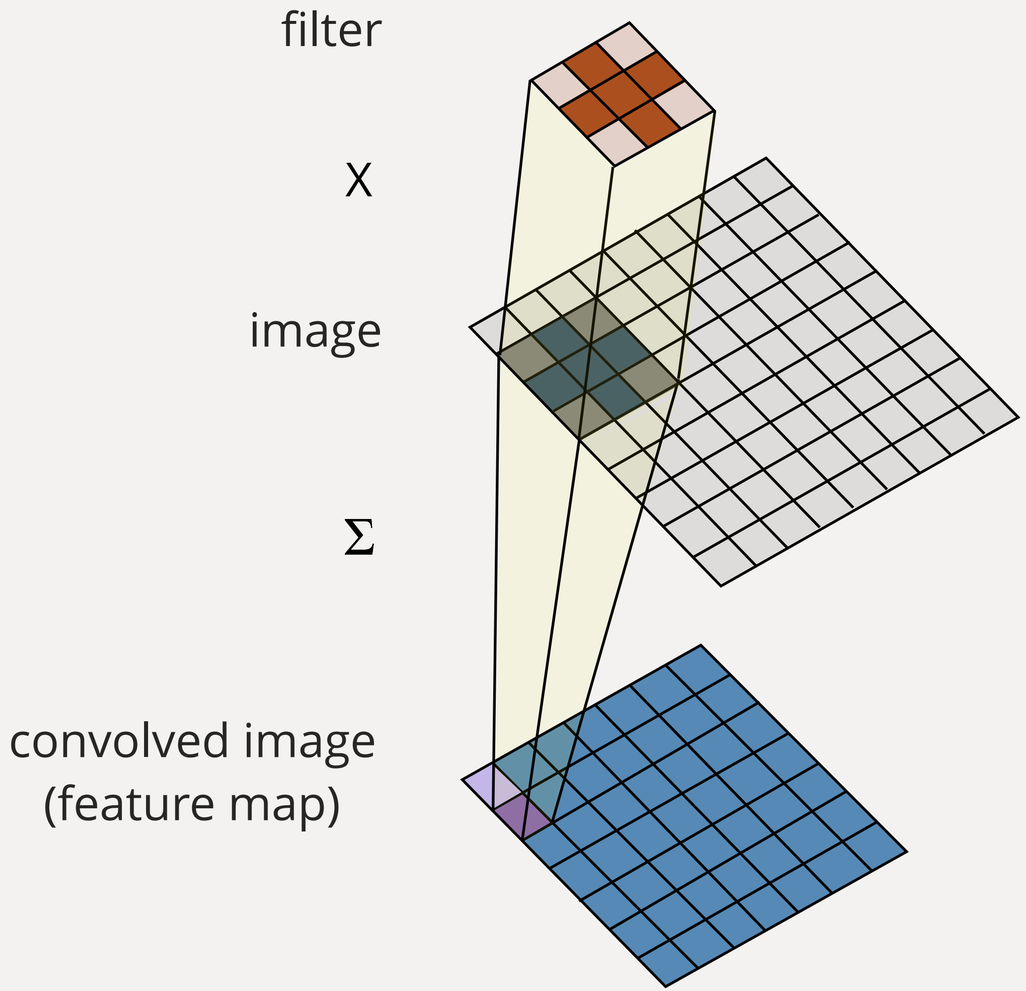
convolved image
(feature map)



2D Spatial Convolution



2D Spatial Convolution



2D Spatial Convolution

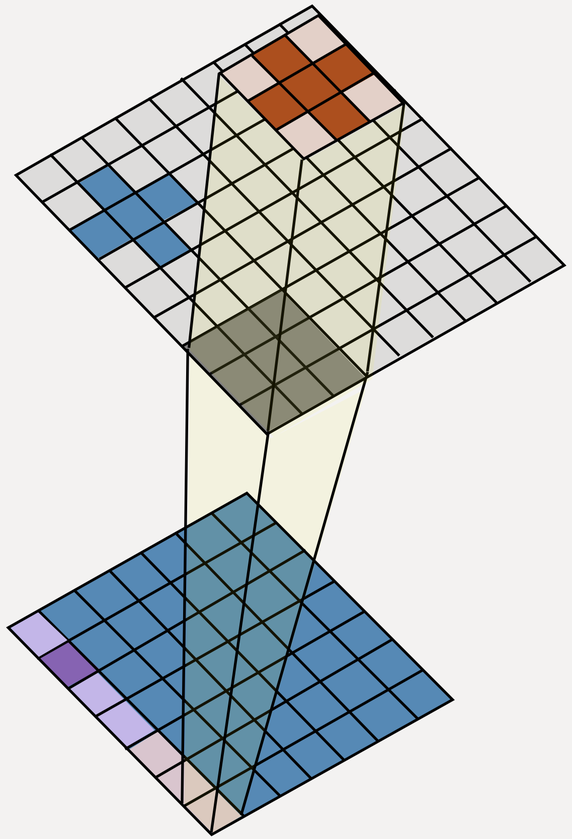
filter

X

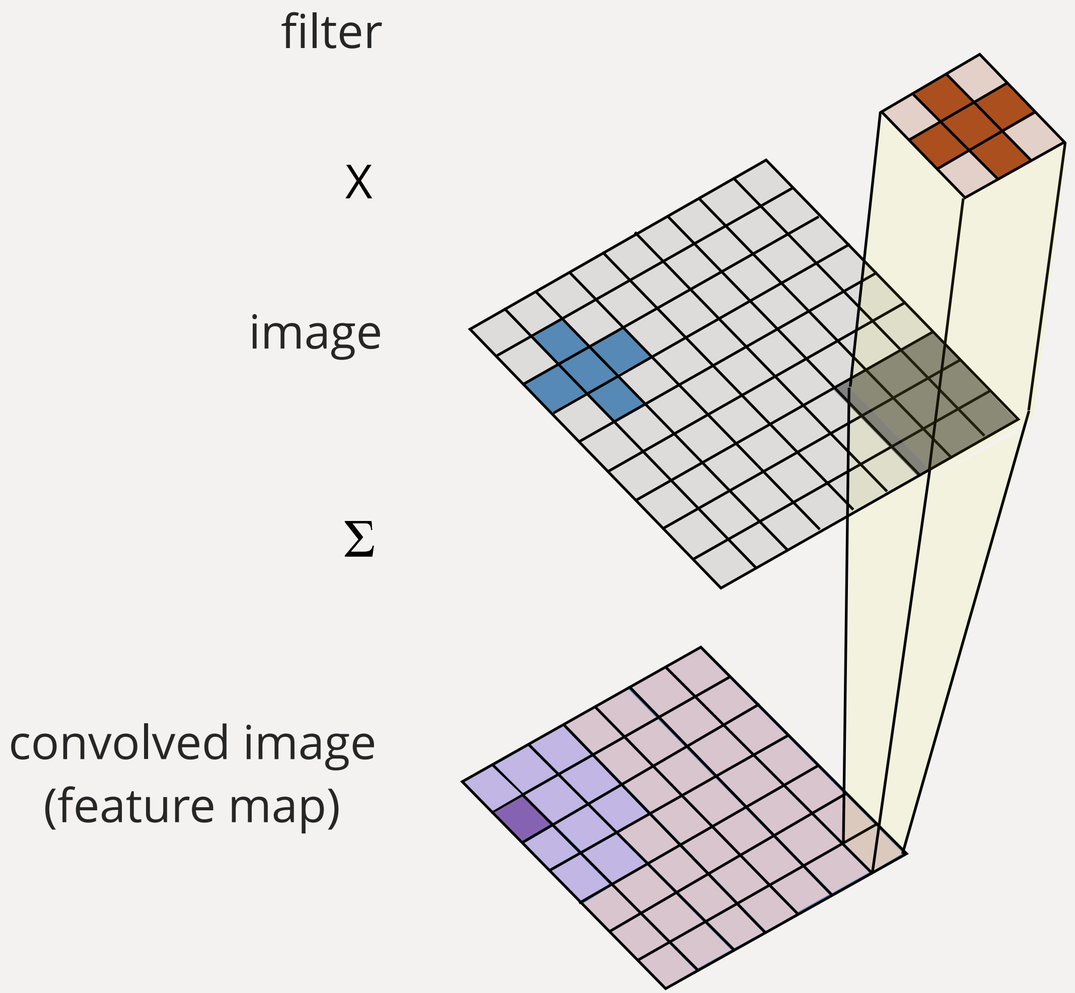
image

Σ

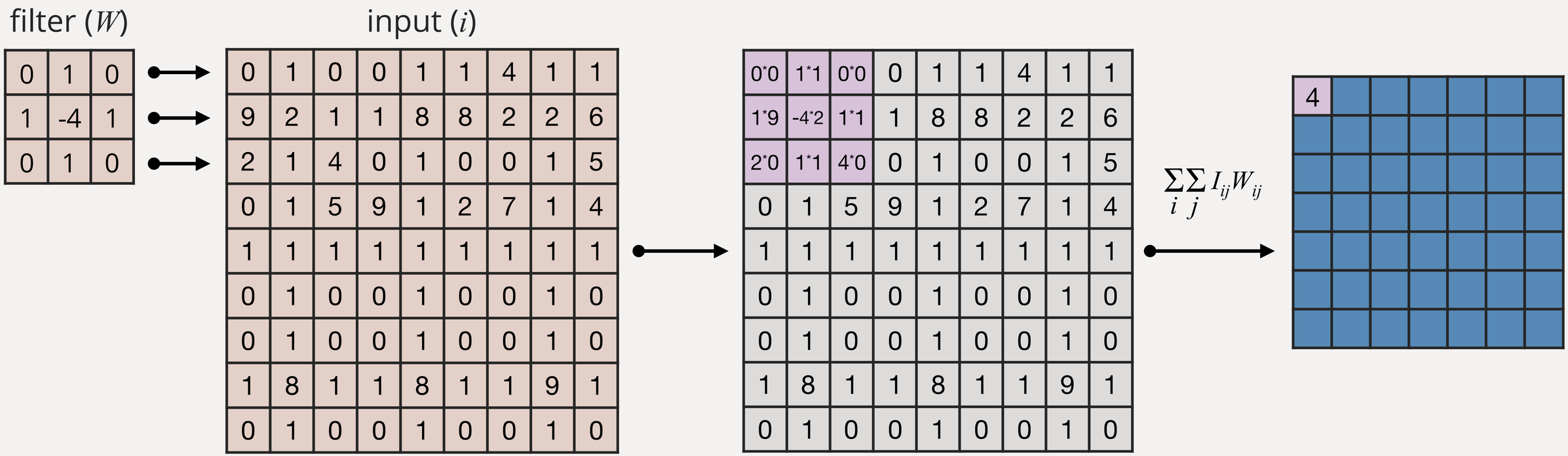
convolved image
(feature map)



2D Spatial Convolution

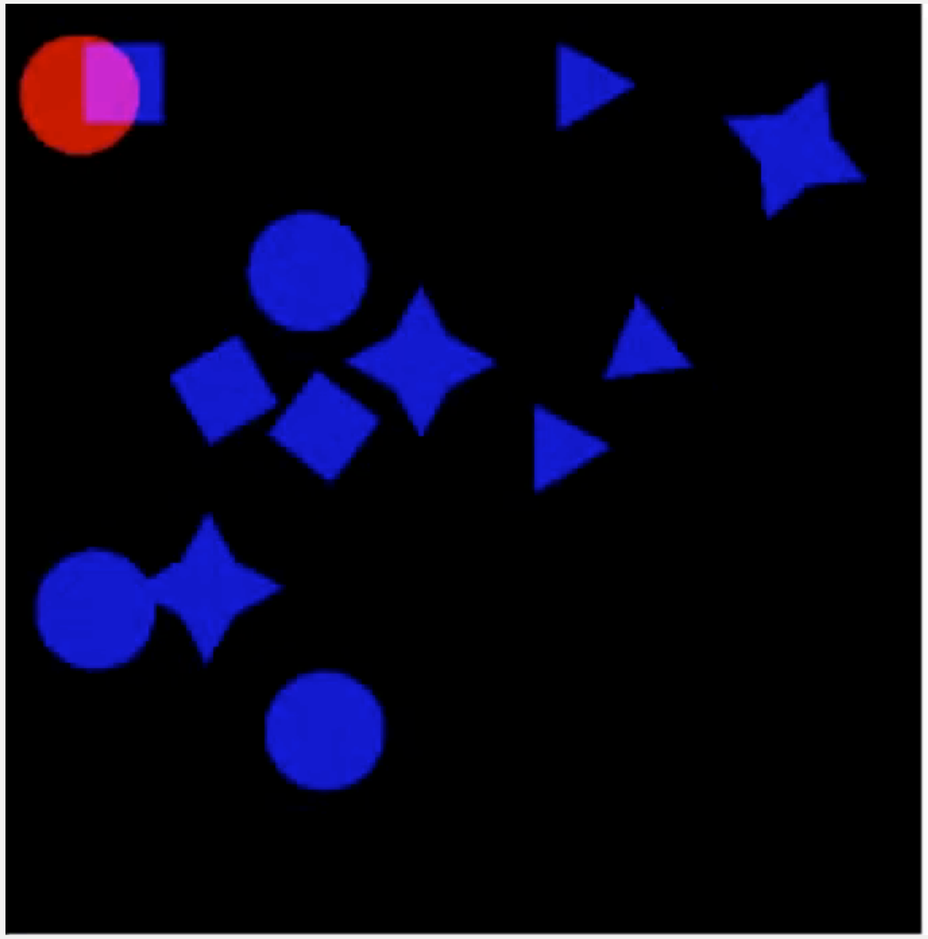
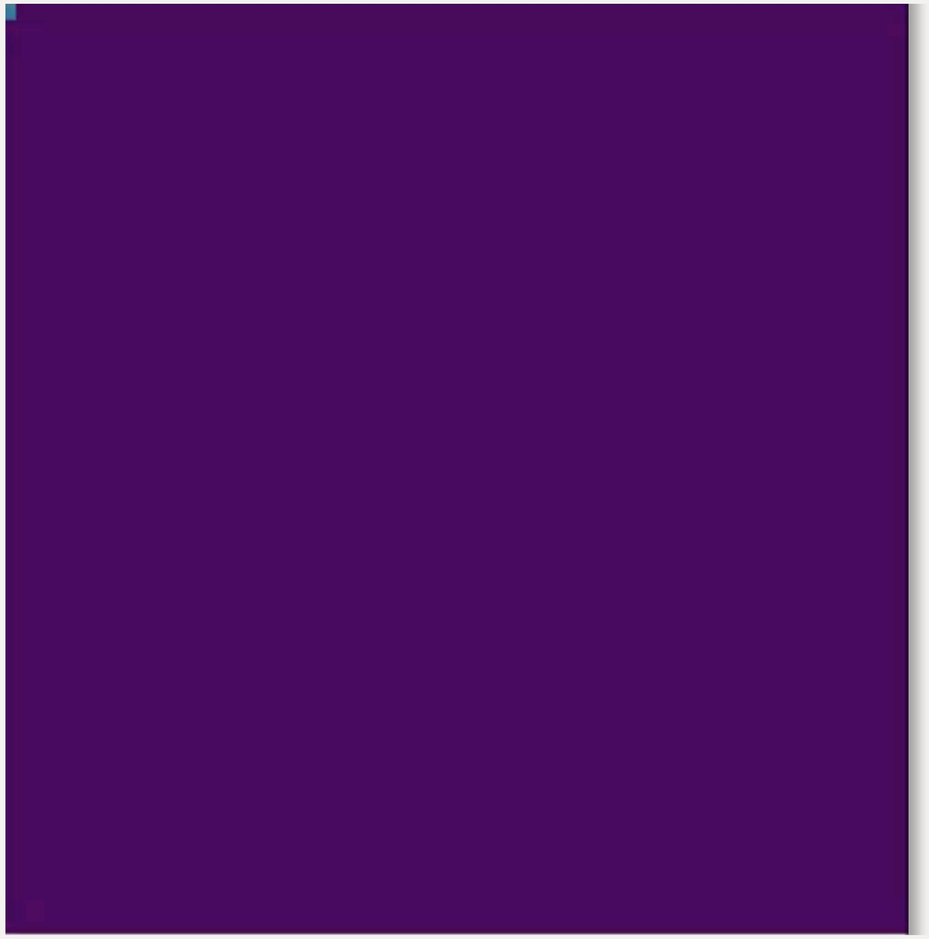
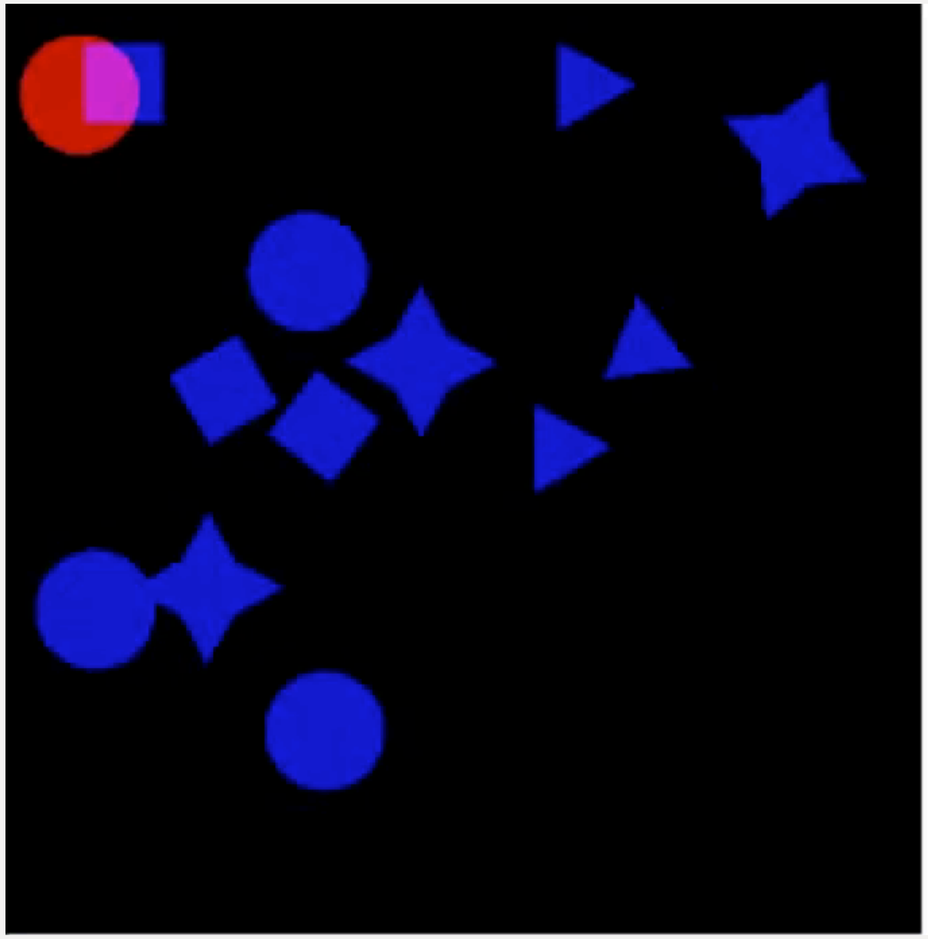
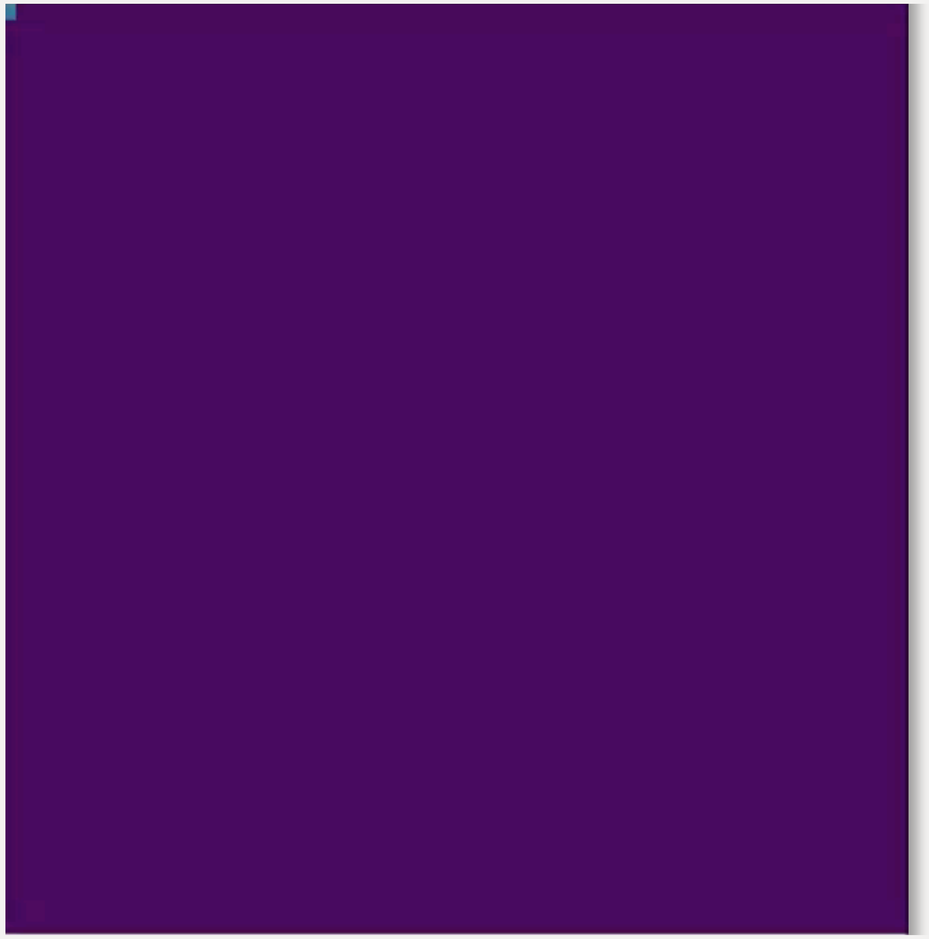


2D Spatial Convolution



2D Spatial Convolution

filter (W)

0	1	0
1	-4	1
0	1	0

input (i)