



Box Filter

## The 'Box' filter

$$g[\cdot, \cdot] = \frac{1}{9} \begin{array}{|c|c|c|} \hline | & | & | \\ \hline | & | & | \\ \hline | & | & | \\ \hline \end{array}$$

replaces pixel with local average

has a smoothing effect

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$


$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0								

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0								

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10							

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10							

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20						

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black



$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20						

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30					

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30	30				

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30	30	30			

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20		

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

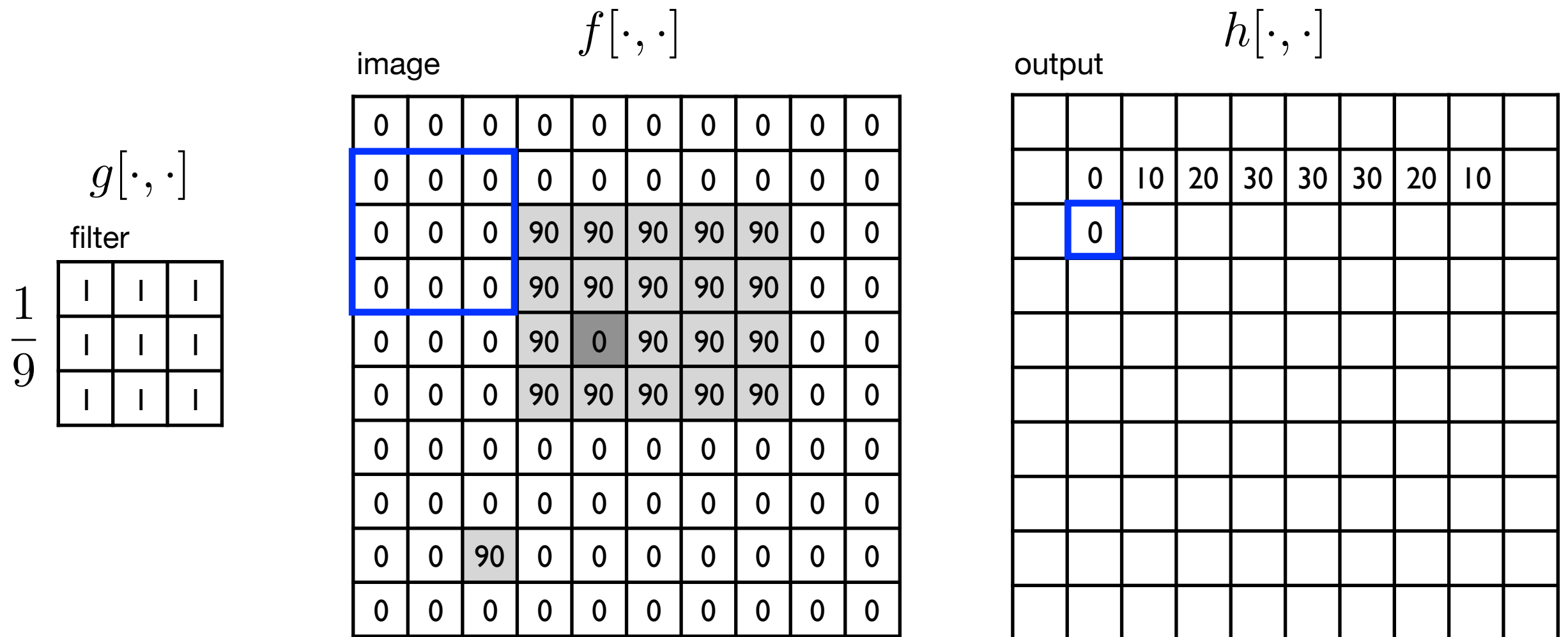
output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20	10	

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black



$$\underset{\text{output}}{h[m, n]} = \sum_{k, l} \underset{\text{filter}}{g[k, l]} \underset{\text{image (signal)}}{f[m + k, n + l]}$$

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20	10	
	0	20							

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black



$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

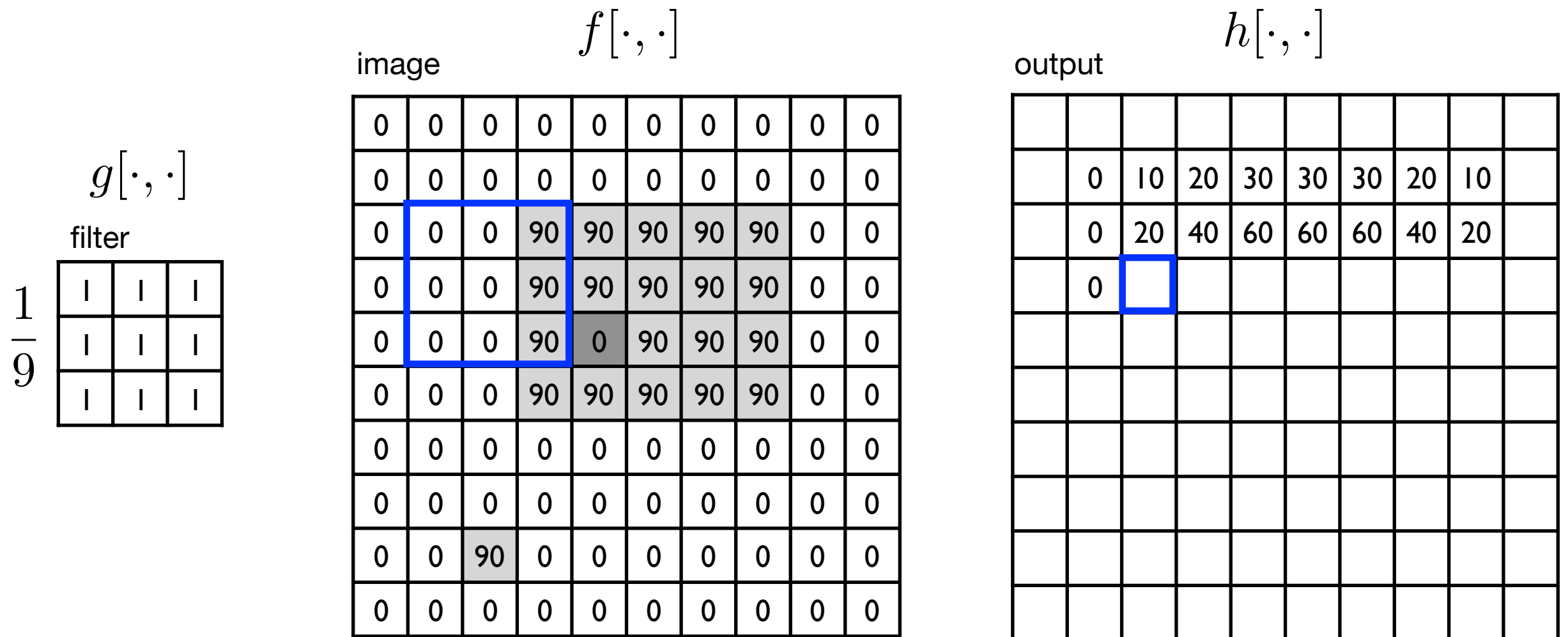
output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20	10	
	0	20	40						

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black



$$\underset{\text{output}}{h[m, n]} = \sum_{k, l} \underset{\text{filter}}{g[k, l]} \underset{\text{image (signal)}}{f[m + k, n + l]}$$

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

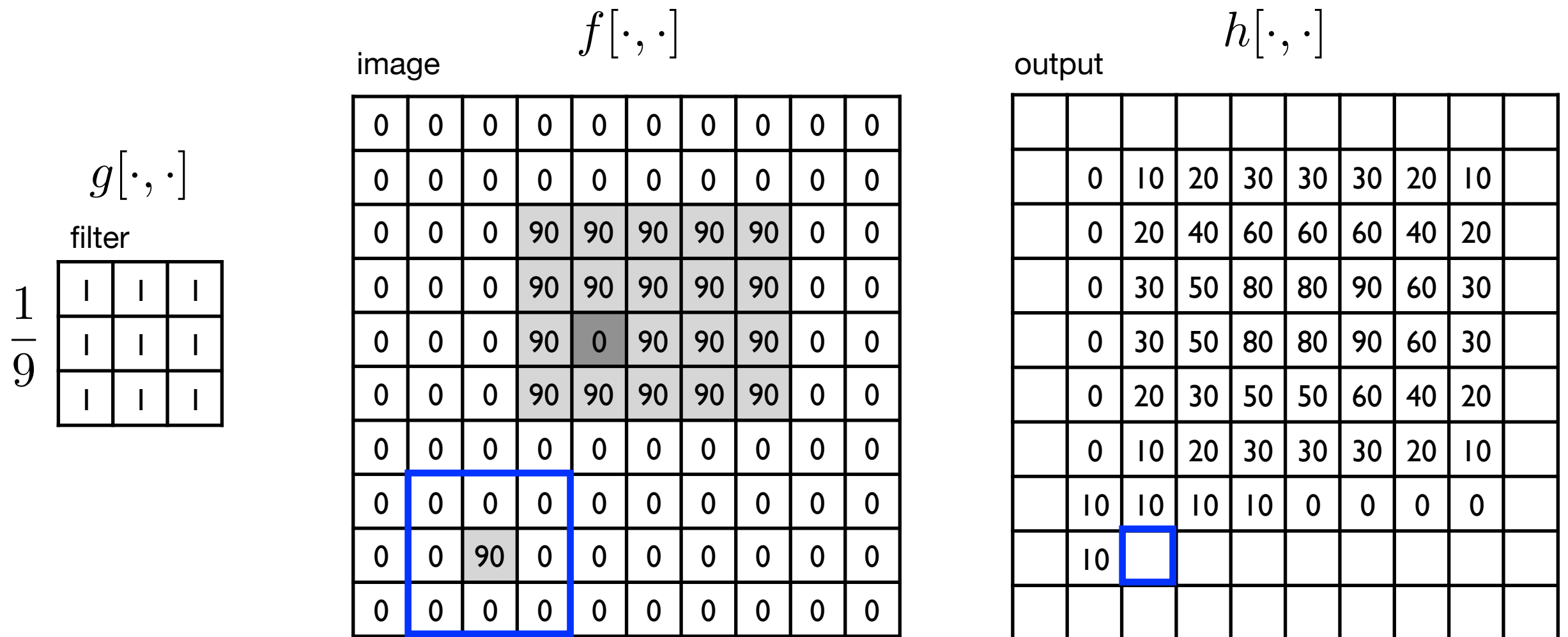
output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20	10	
	0	20	40	60	60	60	40	20	
	0	30							

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output
 $k, l$ 
filter
image (signal)

\* some zero values are white for visualization but they should be black



$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output
 $k, l$ 
filter
image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20	10	
	0	20	40	60	60	60	40	20	
	0	30	50	80	80	90	60	30	
	0	30	50	80	80	90	60	30	
	0	20	30	50	50	60	40	20	
	0	10	20	30	30	30	20	10	
	10	10	10	10	0	0	0	0	
	10	10	10	10	0	0	0	0	

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output       $k, l$       filter      image (signal)

\* some zero values are white for visualization but they should be black

$$\frac{1}{9} g[\cdot, \cdot]$$

1	1	1
1	1	1
1	1	1

filter

image  $f[\cdot, \cdot]$

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	90	0	90	90	90	0	0
0	0	0	90	90	90	90	90	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	90	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

output  $h[\cdot, \cdot]$

	0	10	20	30	30	30	20	10	
	0	20	40	60	60	60	40	20	
	0	30	50	80	80	90	60	30	
	0	30	50	80	80	90	60	30	
	0	20	30	50	50	60	40	20	
	0	10	20	30	30	30	20	10	
	10	10	10	10	0	0	0	0	
	10	10	10	10	0	0	0	0	

$$h[m, n] = \sum_{k, l} g[k, l] f[m + k, n + l]$$

output  $k, l$  filter image (signal)

\* some zero values are white for visualization but they should be black

