

# **Smoothing Filters**

Blurring

# Smoothing

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- Smoothing filter will blur the image.
- Each pixel in the image is mixed in with its surrounding pixel intensities. This mixture of pixels in a neighborhood becomes our blurred pixel.
- This effect is quite helpful while performing image processing tasks.

# Types of Smoothing Filters

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1. Averaging
2. Median
3. Gaussian

# Averaging

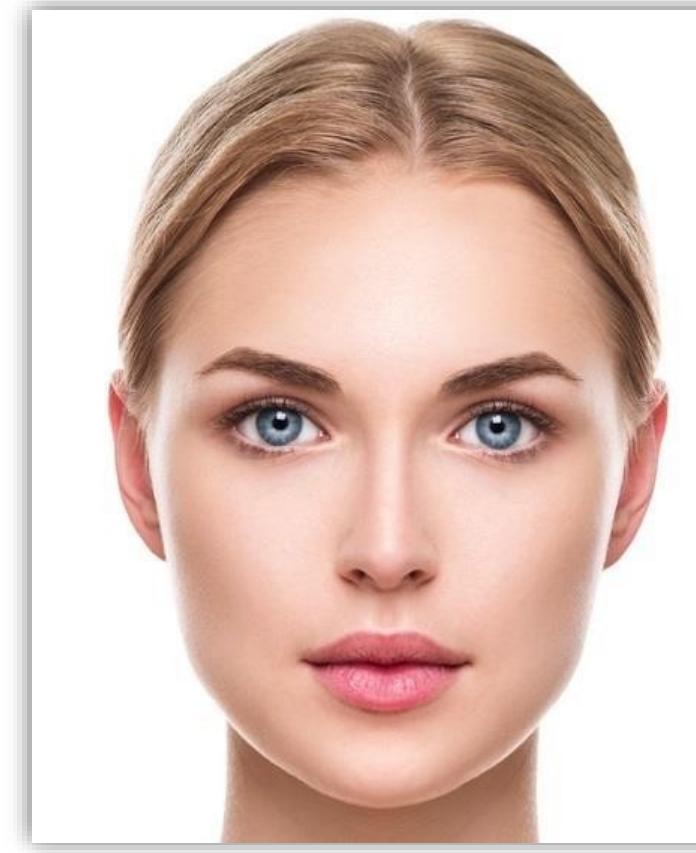
## Smoothing Filter

# Averaging Blur

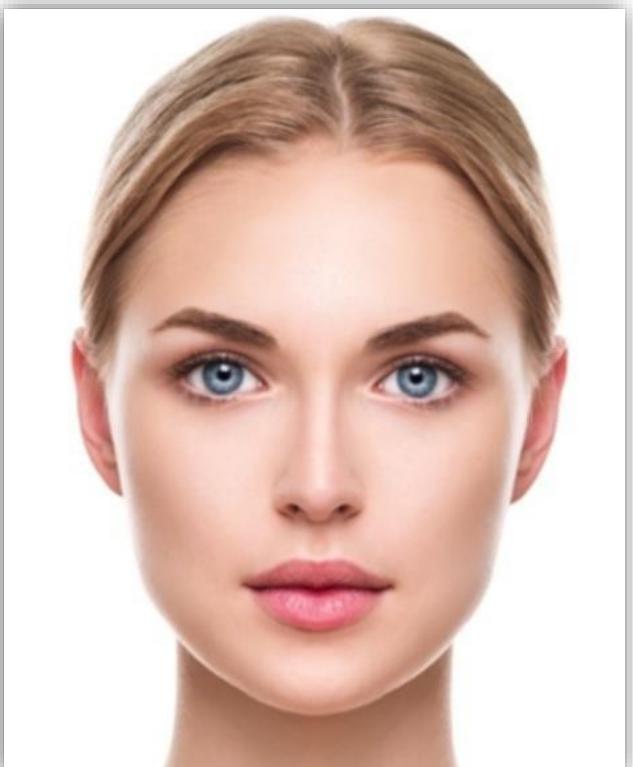
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- Step-1: Define  $k \times k$  sliding window on top of the image.
  - $k$  is always odd number
- Step-2: Slide the window from left to right and top to bottom
- Step-3: For each stride (usually stride = 1), pixel at the center of the matrix is **average** of pixels surrounding it.

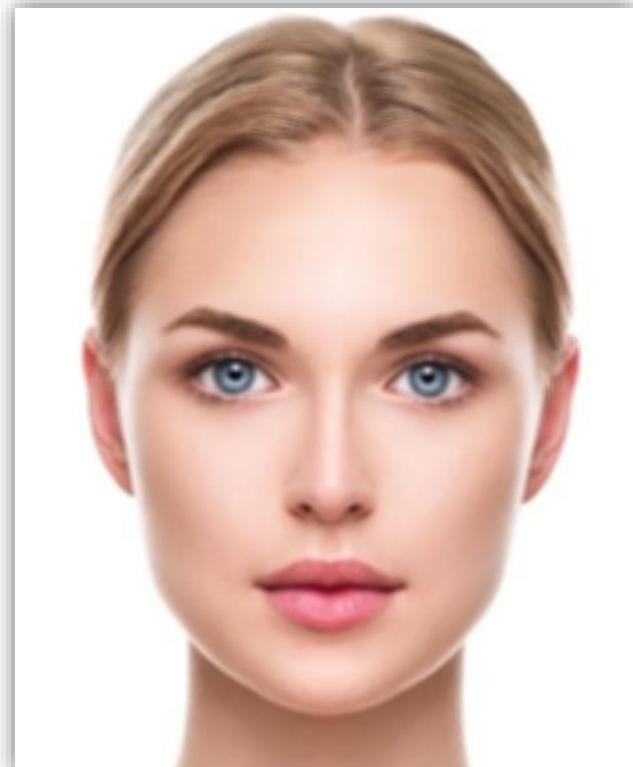
# If size of sliding window increases blur effect increases



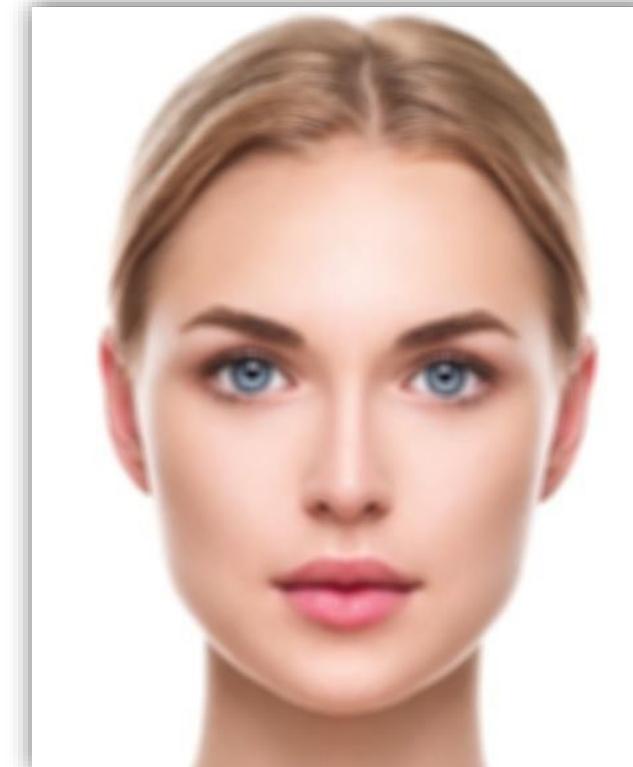
**(3 x 3)**



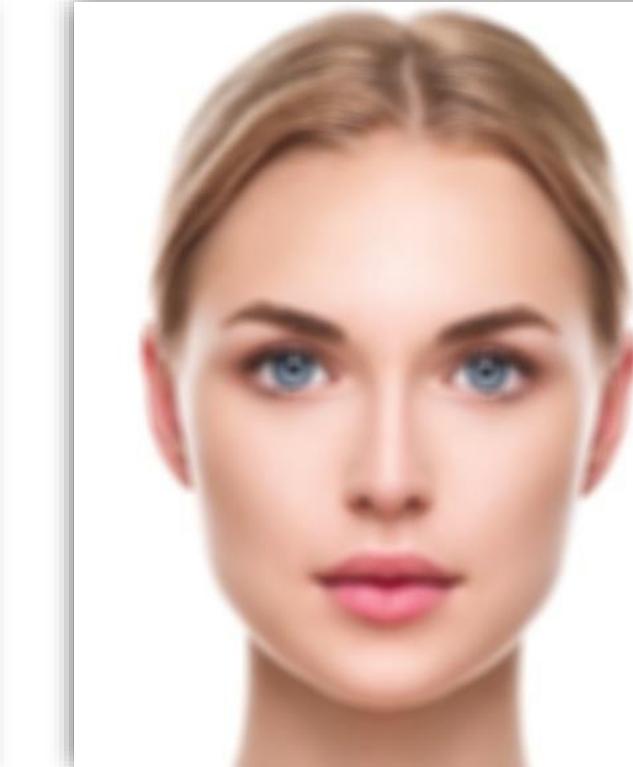
**(5 x 5)**



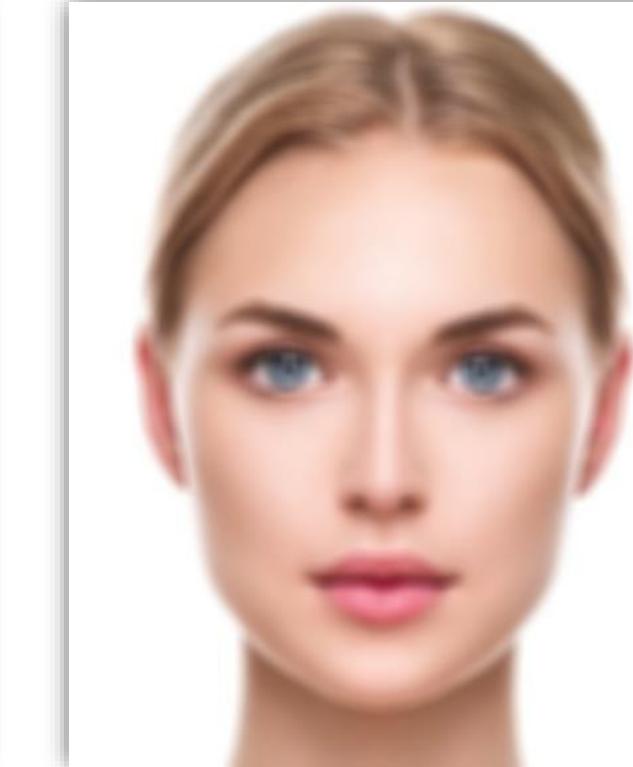
**(7 x 7)**



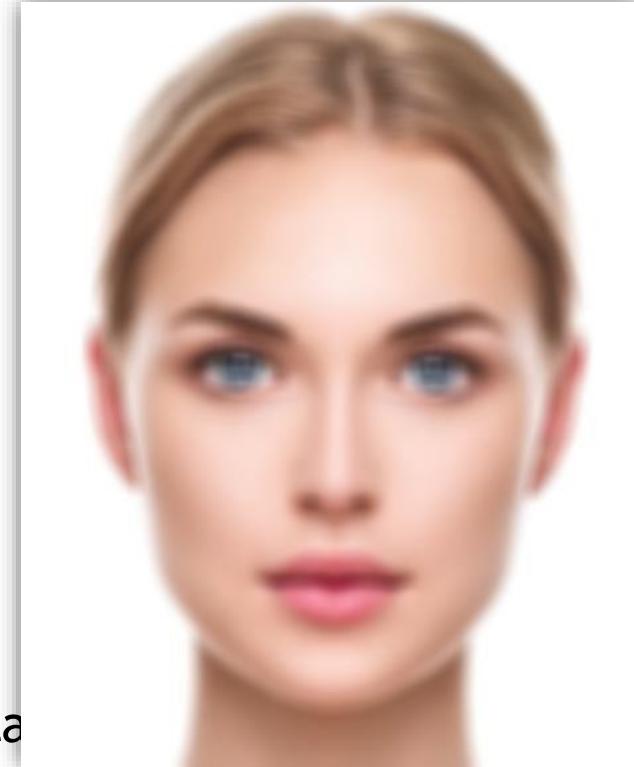
**(9 x 9)**



**(11 x 11)**

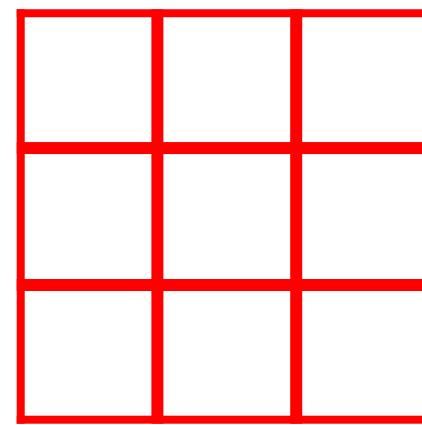


**(13 x 13)**

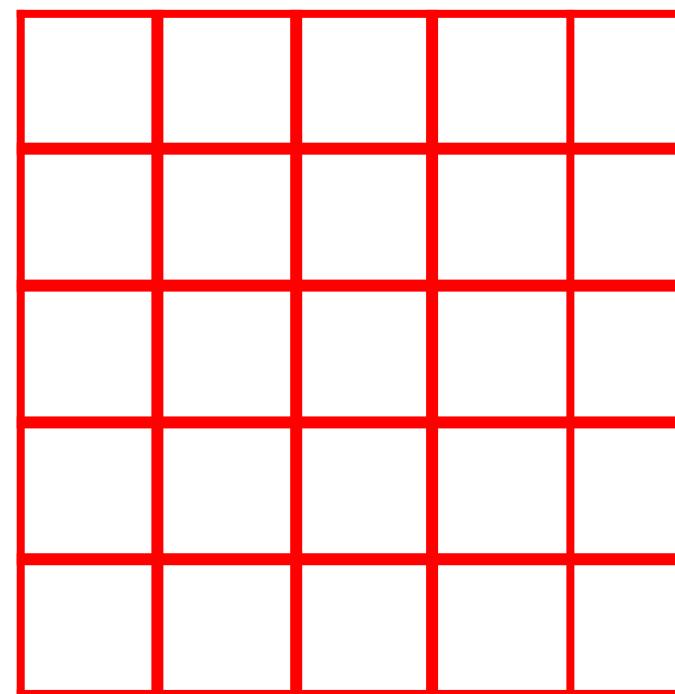


# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



3 × 3



5 × 5

# Convolve Process

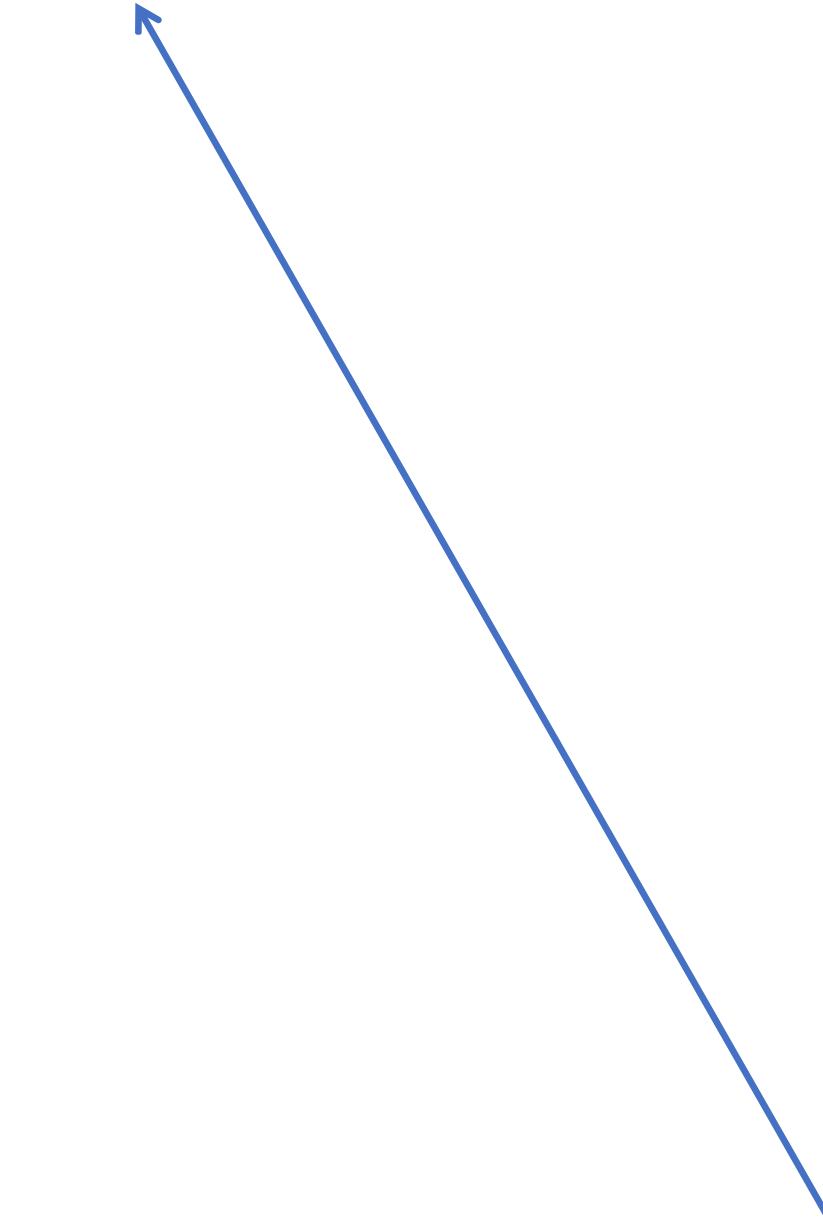
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

Average  
=

$$\frac{20+100+73+200+102+16+27+212+23}{9} = 85$$



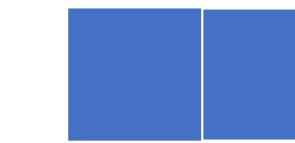
# Convolve Process

Stride = 1

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

Average  
=

$$\frac{100+73+60+102+16+56+212+23+36}{9} = 75$$

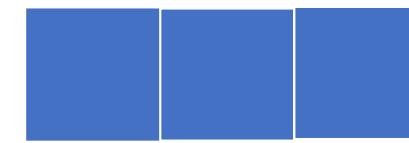


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



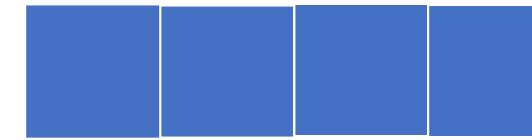
Average  
=

# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

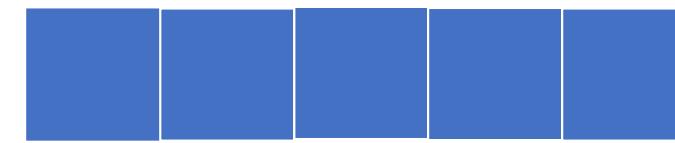


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

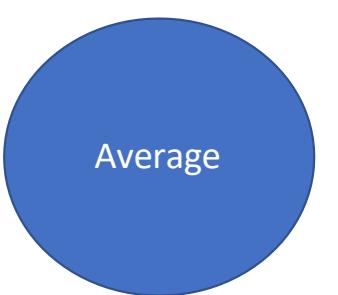
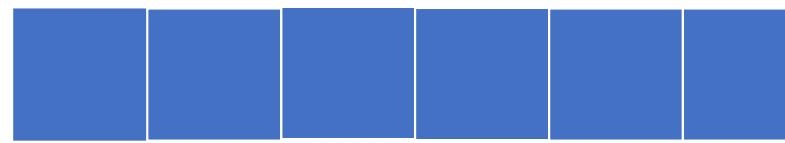


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

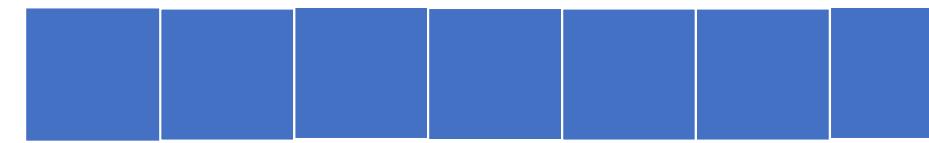


# Convolve Process

Stride = 1

→

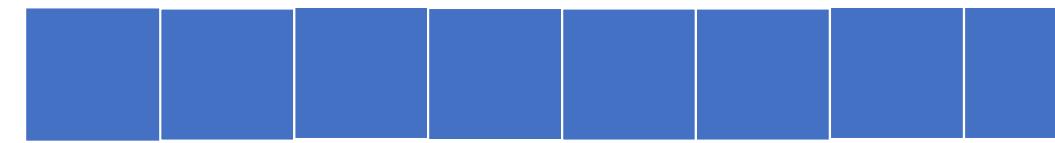
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

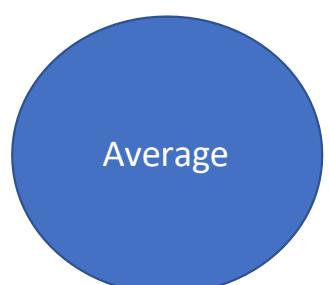
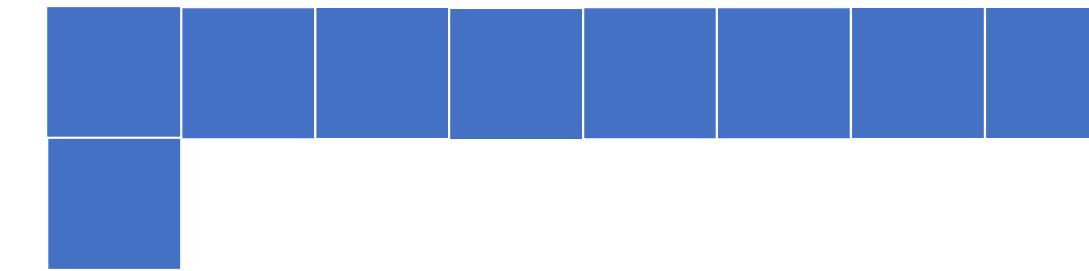
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

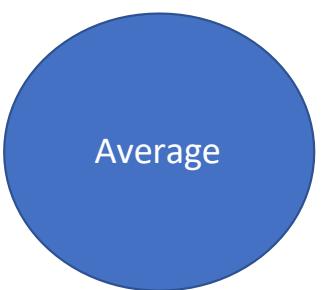
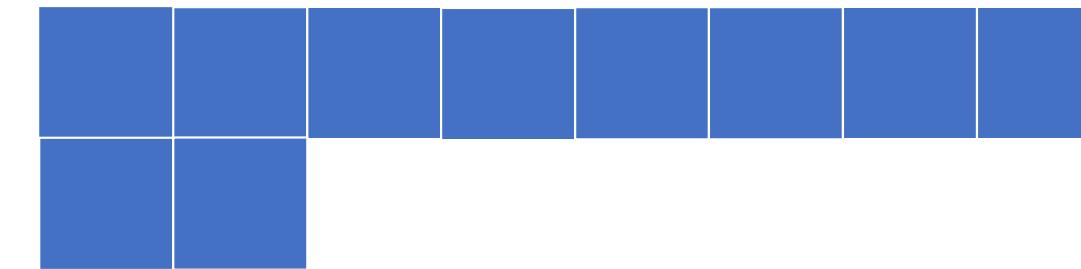


# Convolve Process

Stride = 1



20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

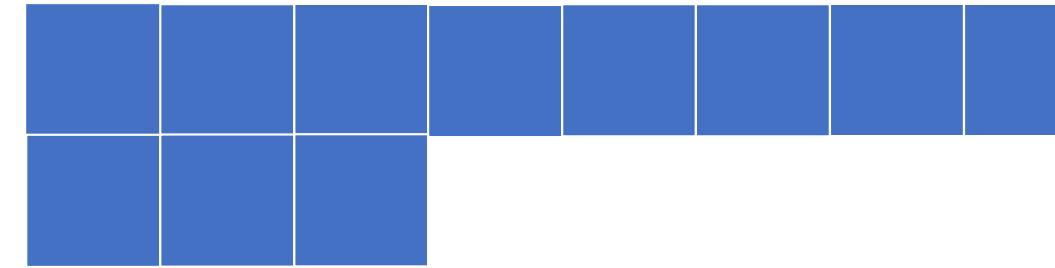


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
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19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

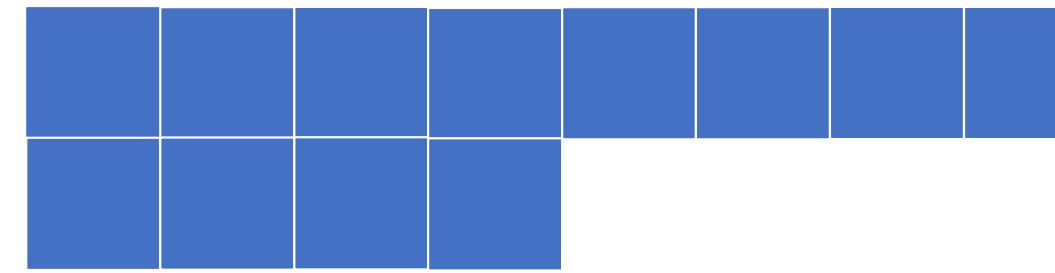


# Convolve Process

Stride = 1

→

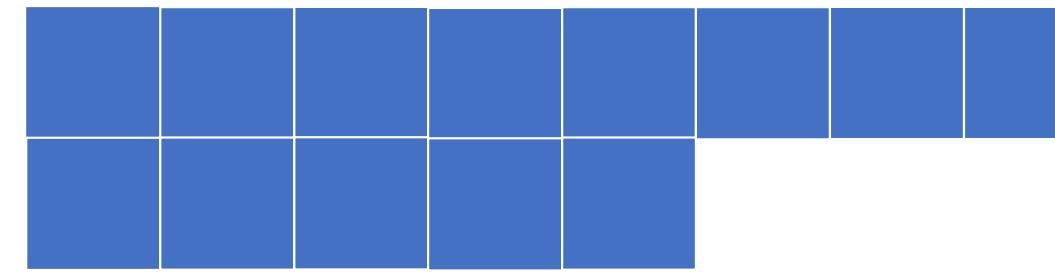
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

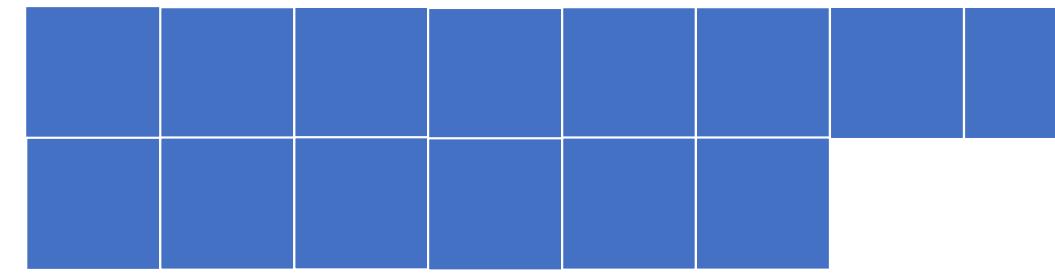


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
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19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
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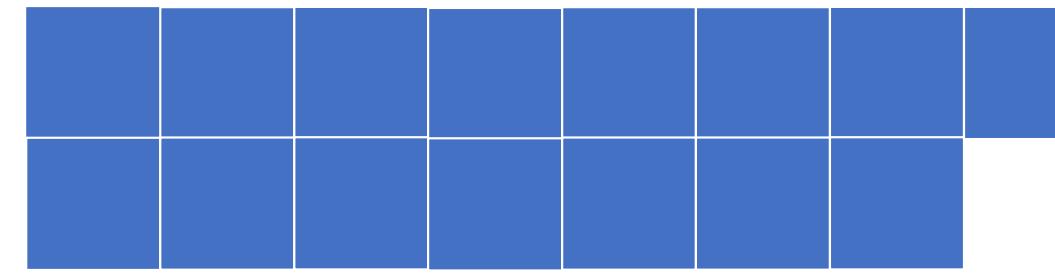


# Convolve Process

Stride = 1

→

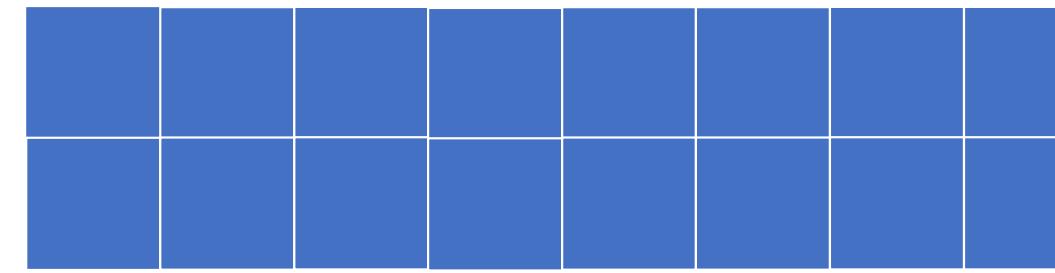
20	100	73	60	82	76	250	189	212	56	
200	102	16	56	28	67	240	190	63	09	
27	212	23	36	82	55	156	18	70	65	
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19	212	23	36	82	55	156	18	70	82	
108	100	73	60	82	76	250	189	212	19	
123	102	16	56	28	67	240	190	63	165	
200	212	23	36	82	55	156	18	70	198	
35	100	73	60	82	76	250	189	212	31	



# Convolve Process

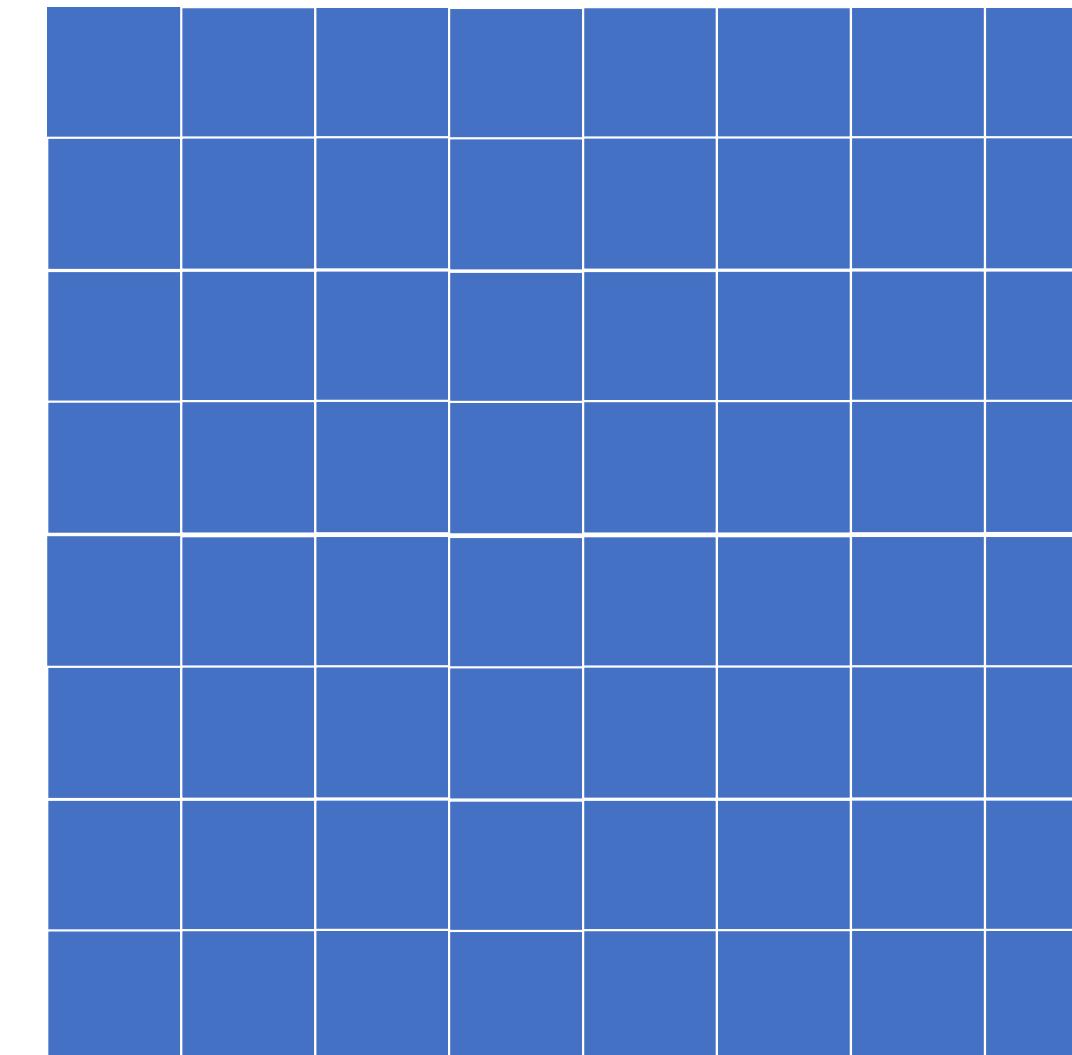
Stride = 1  
→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



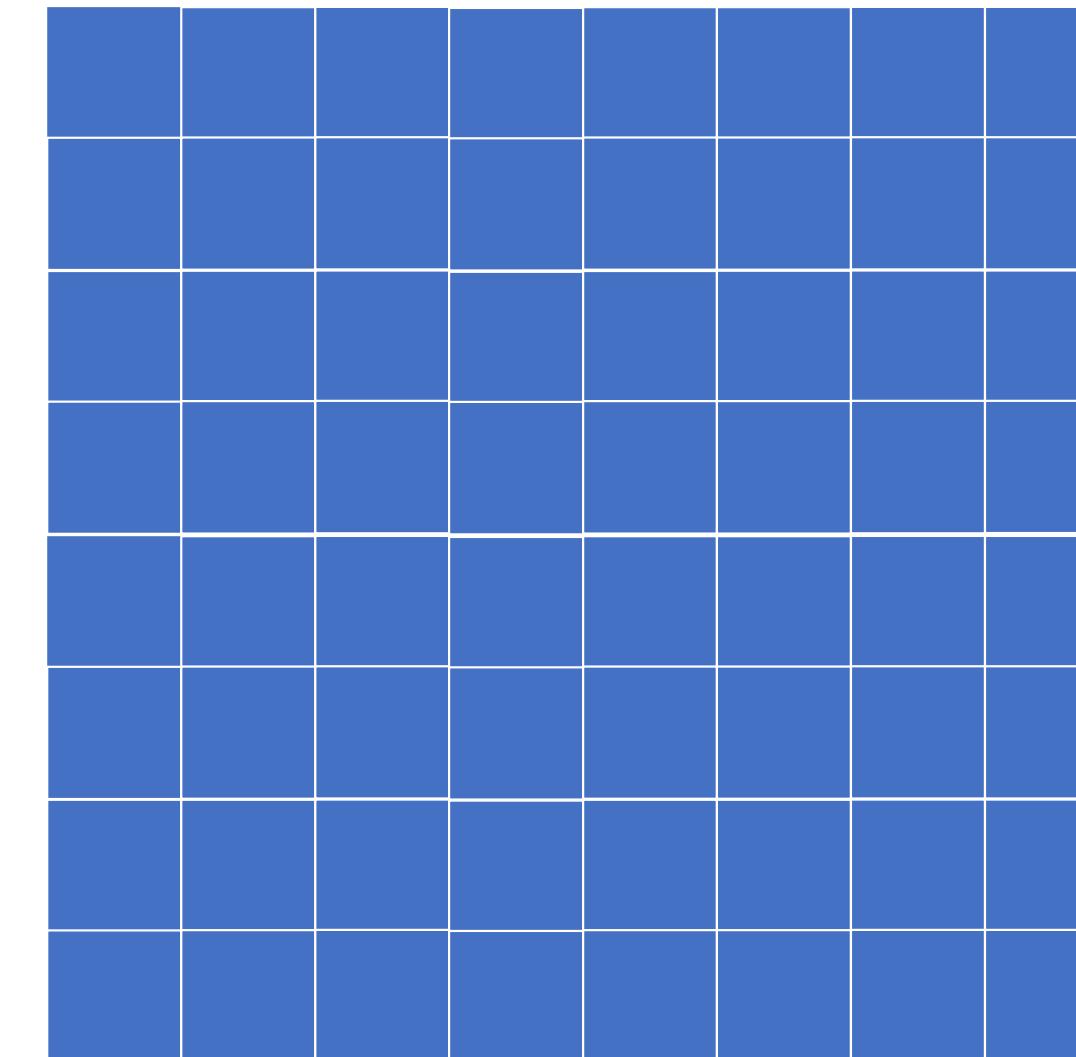
# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
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108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
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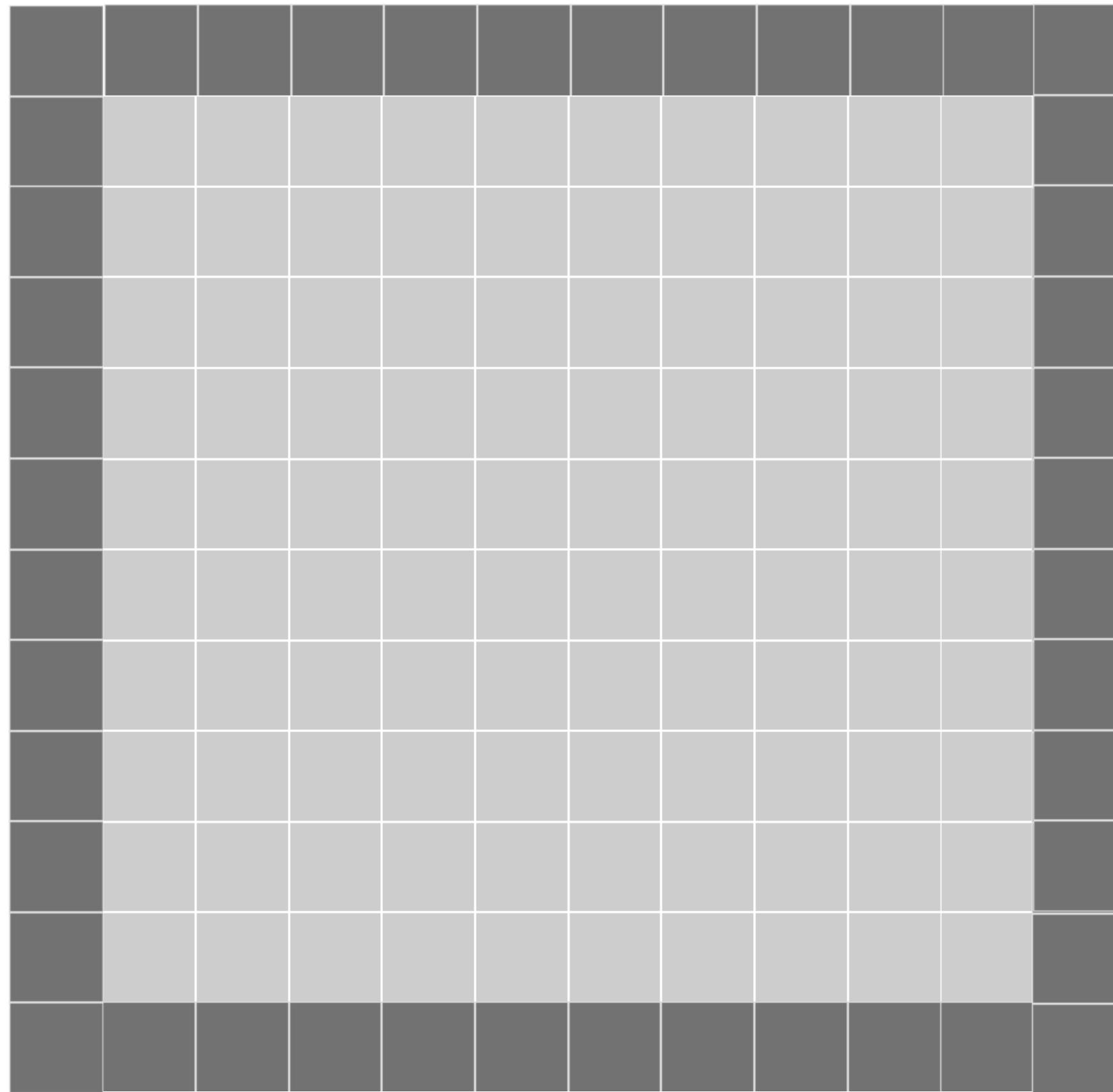
# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
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35	100	73	60	82	76	250	189	212	31

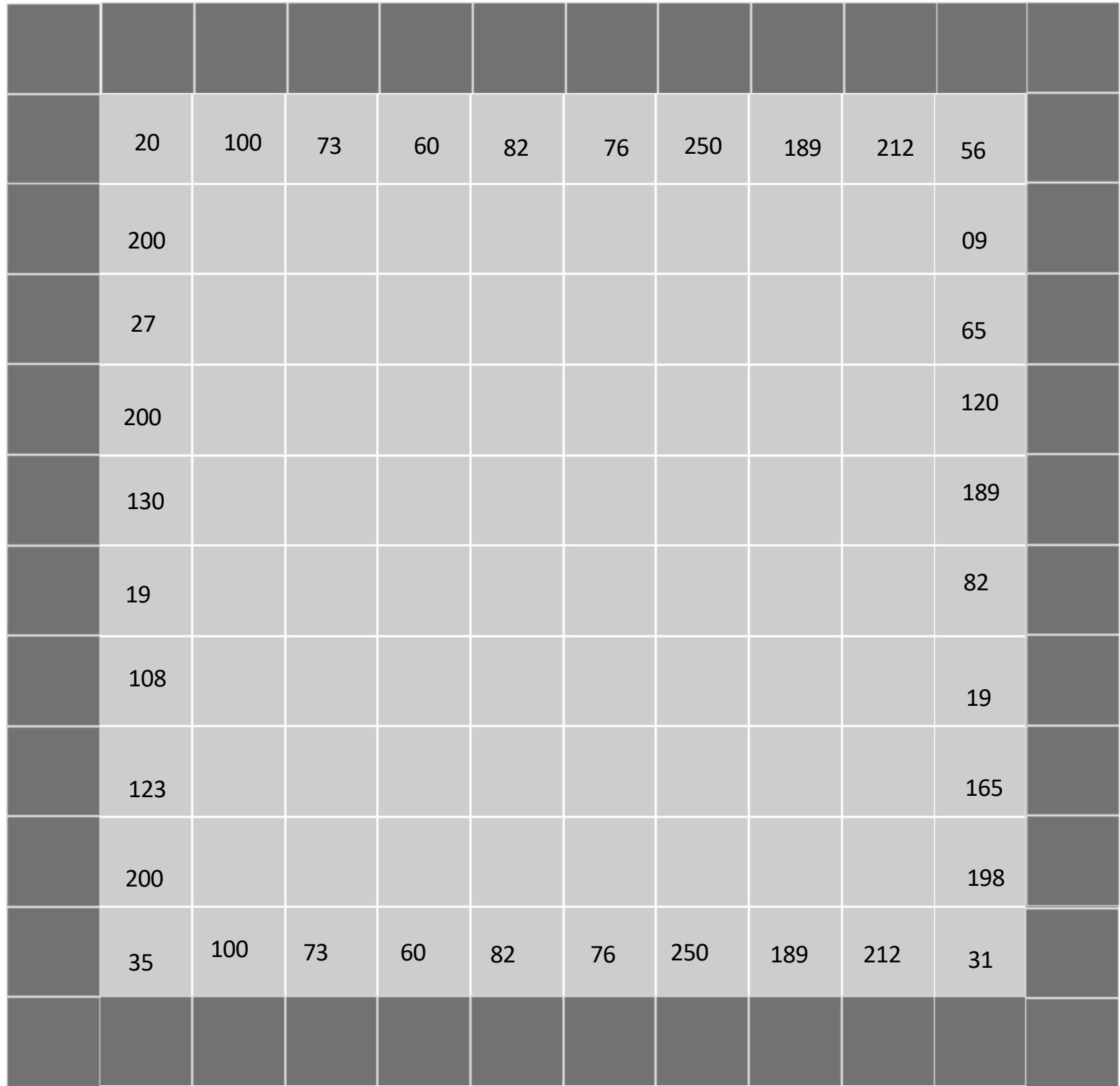


# Padding to Retail the W & H

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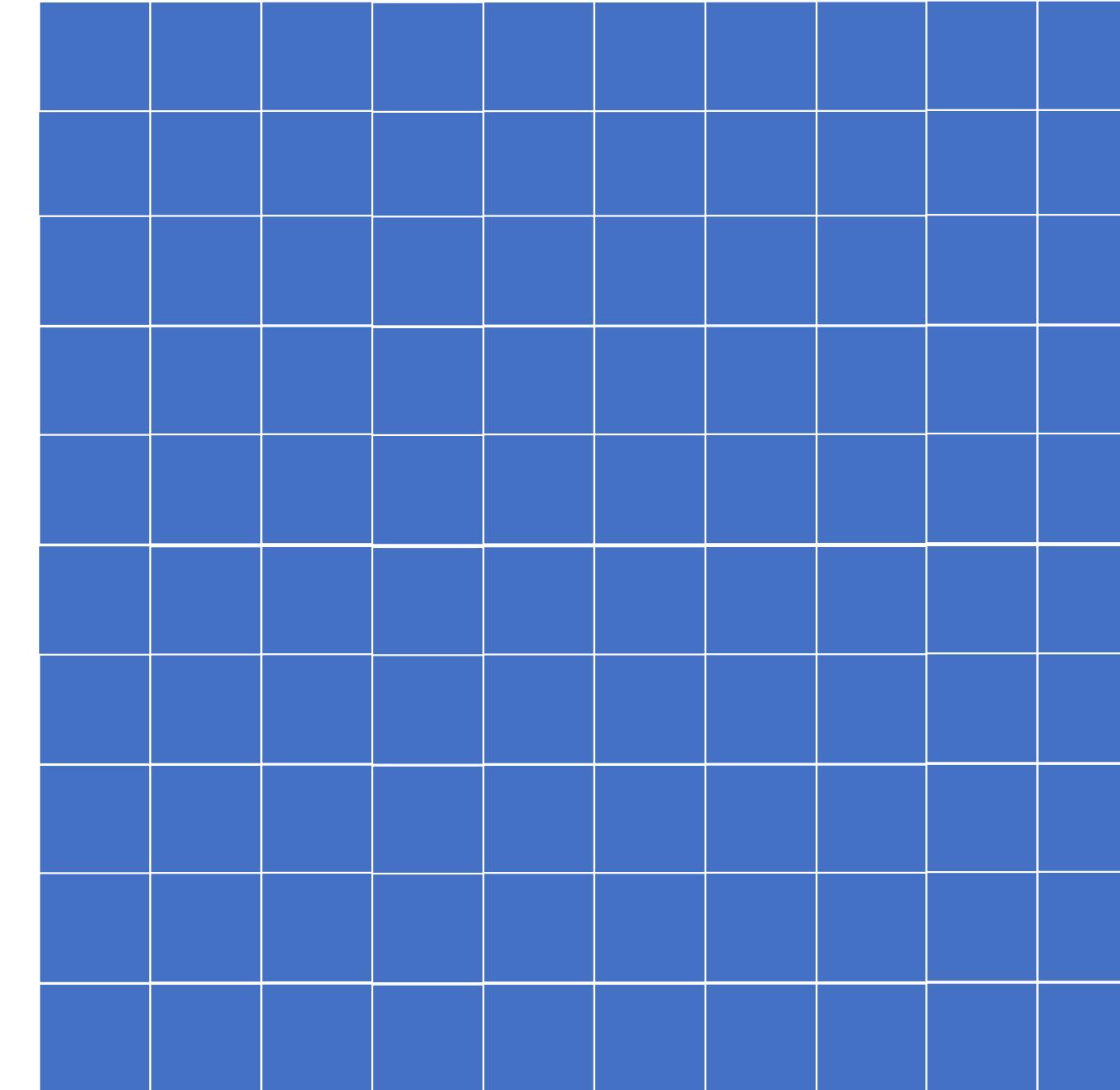
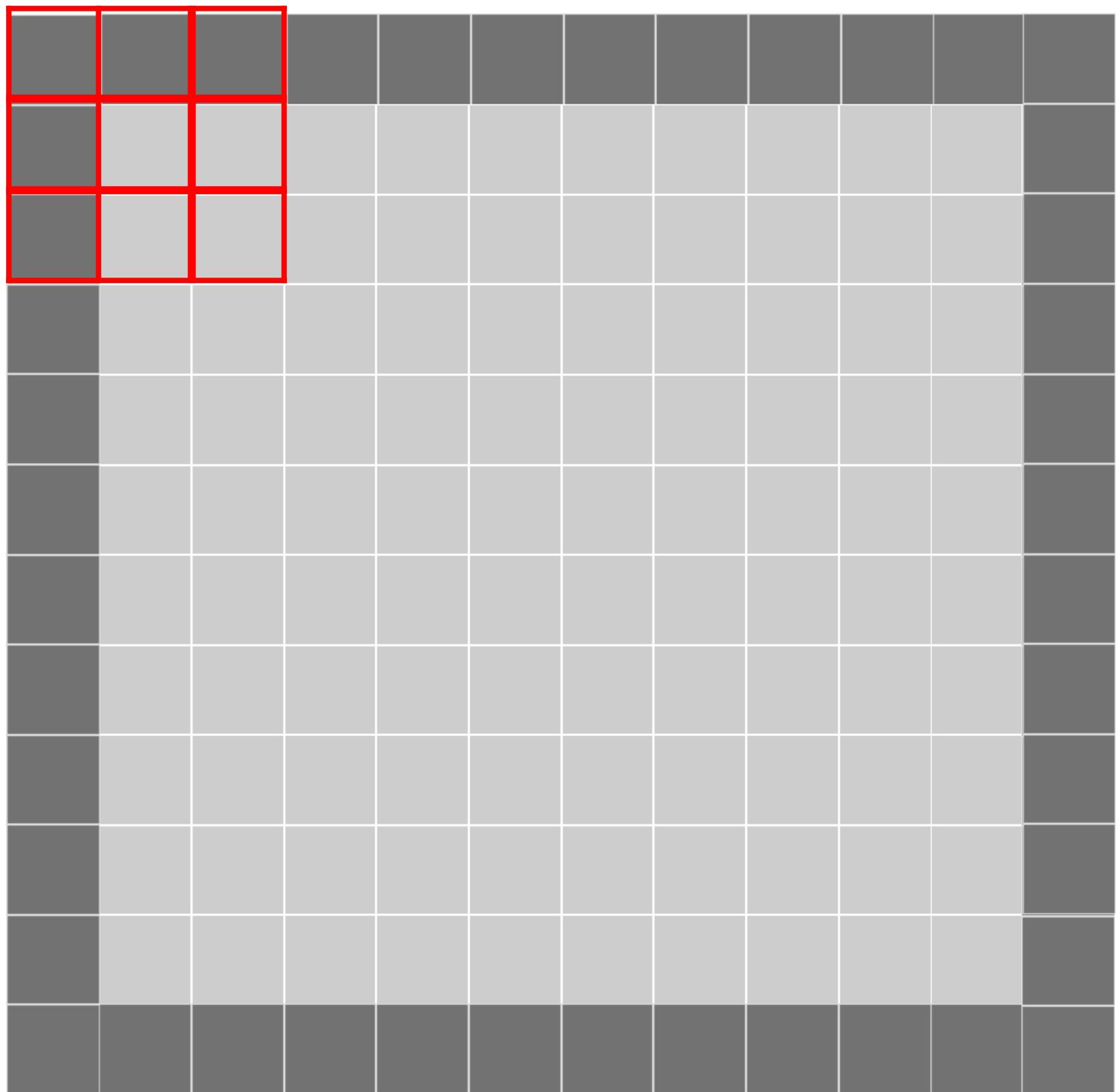


# Same Padding



# Same Padding or Zero Padding

# Apply Convolve



Average

# Average Blur in OpenCV

---

```
cv2.blur(src,ksize)
```

# Gaussian Blur

Smoothing Filter

# Gaussian Blur

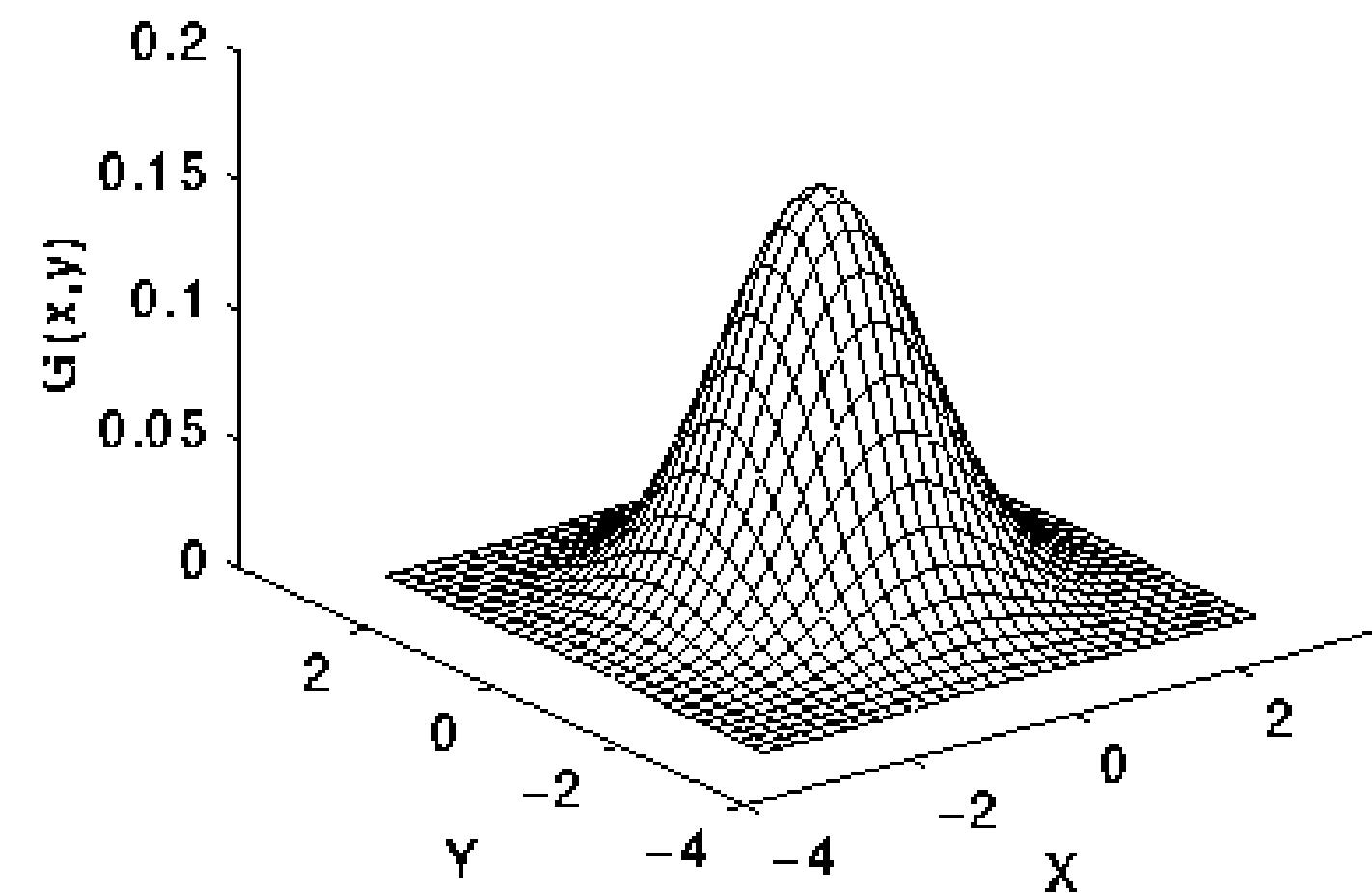
---

- Step-1: Define  $k \times k$  sliding window on top of the image.
  - $k$  is always odd number
- Step-2: Slide the window from left to right and top to bottom
- Step-3: For each stride (usually stride = 1), pixel at the center of the matrix is weight mean, where neighbourhood pixels that are closer to the **central pixel contribute more “weight”** to the average.

# Gaussian Blur

- In 2-D, an isotropic Gaussian has the form:

$$G(x, y) = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2+y^2}{2\sigma^2}}$$



$$\frac{1}{273}$$

1	4	7	4	1
4	16	26	16	4
7	26	41	26	7
4	16	26	16	4
1	4	7	4	1

# Gaussian Blur Kernel

$$3 \times 3 \longrightarrow \frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

$$5 \times 5 \longrightarrow \frac{1}{256} \begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 4 & 16 & 24 & 16 & 4 \\ 6 & 24 & 36 & 24 & 6 \\ 4 & 16 & 24 & 16 & 4 \\ 1 & 4 & 6 & 4 & 1 \end{bmatrix}$$

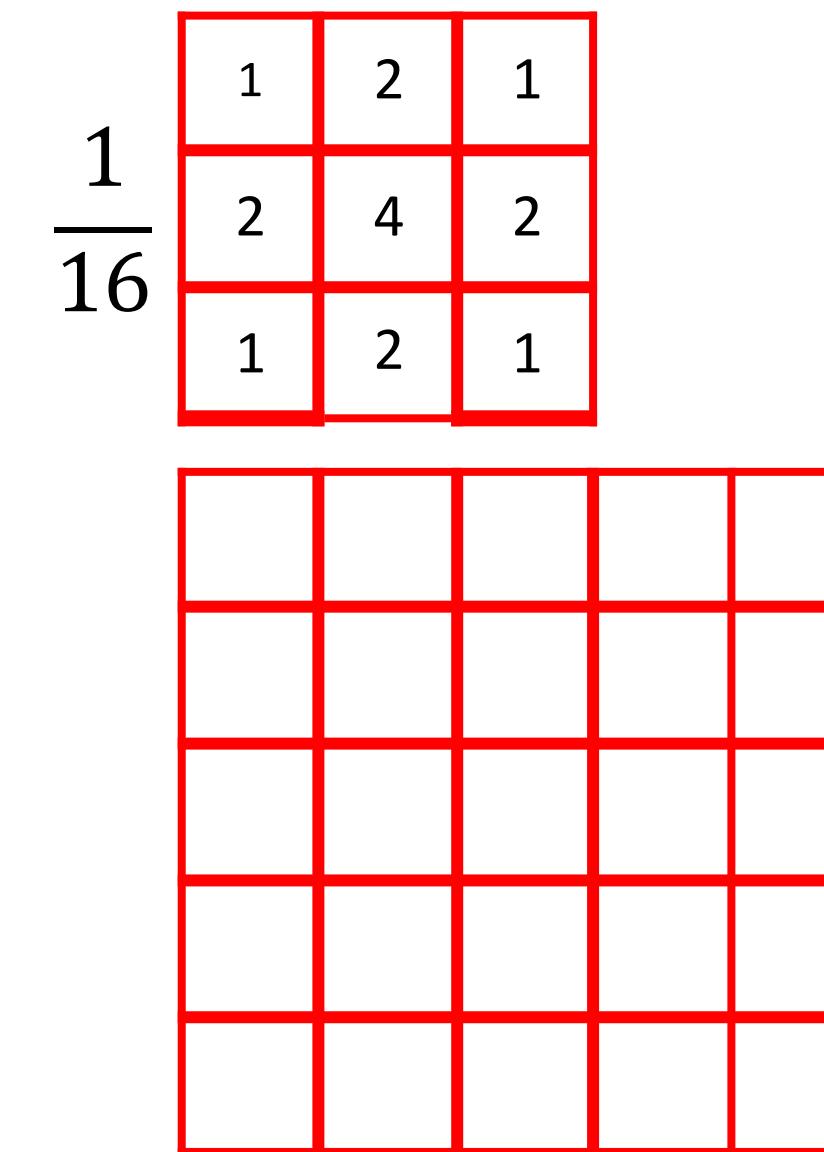
# Gaussian Blur Kernel

---

- As kernel size increases blur effect increases

# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

20	100	73	60	82	76	250	189	212	56	
200	102	16	56	28	67	240	190	63	09	
27	212	23	36	82	55	156	18	70	65	
200	100	73	60	82	76	250	189	212	120	
130	102	16	56	28	67	240	190	63	189	
19	212	23	36	82	55	156	18	70	82	
108	100	73	60	82	76	250	189	212	19	
123	102	16	56	28	67	240	190	63	165	
200	212	23	36	82	55	156	18	70	198	
35	100	73	60	82	76	250	189	212	31	

# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

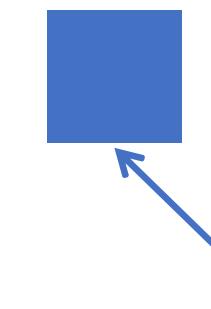
Convolve

$$\begin{bmatrix} 20 & 100 & 73 \\ 200 & 102 & 16 \\ 27 & 212 & 23 \end{bmatrix} * \frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

Convolve



$$\begin{bmatrix} 20 & 100 & 73 \\ 200 & 102 & 16 \\ 27 & 212 & 23 \end{bmatrix} * \frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

$$= 20 * \frac{1}{16} + 100 * \frac{2}{16} + 73 * \frac{1}{16} + 200 * \frac{2}{16} + 102 * \frac{4}{16} + 16 * \frac{2}{16} + 27 * \frac{1}{16} + 212 * \frac{2}{16} + 23 * \frac{1}{16}$$

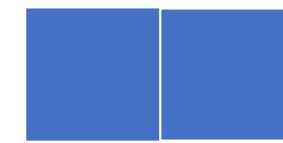
$$= 101$$

# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

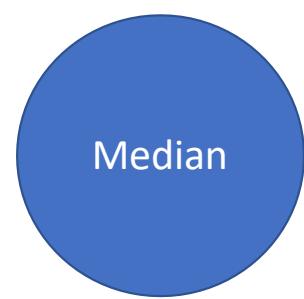
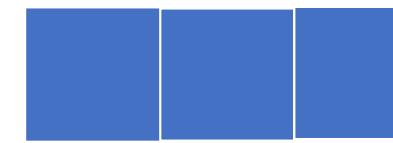


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

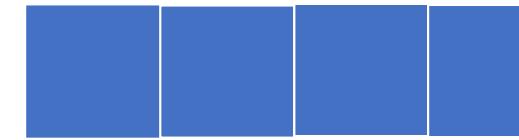


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

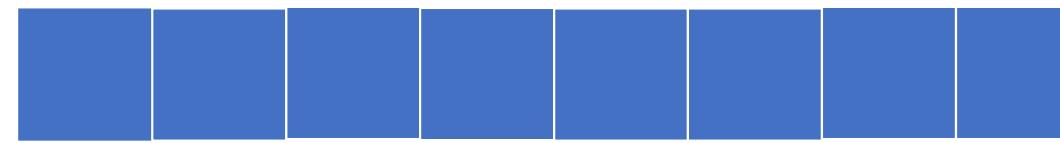
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

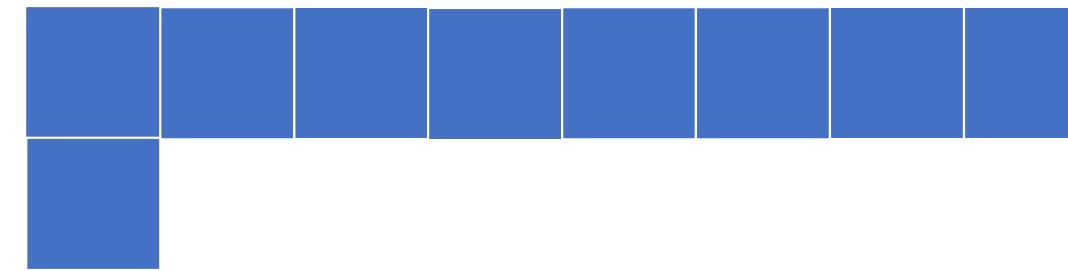
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

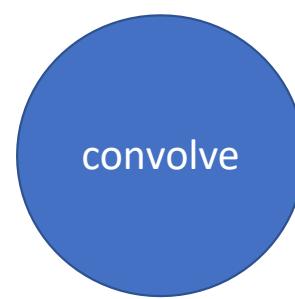
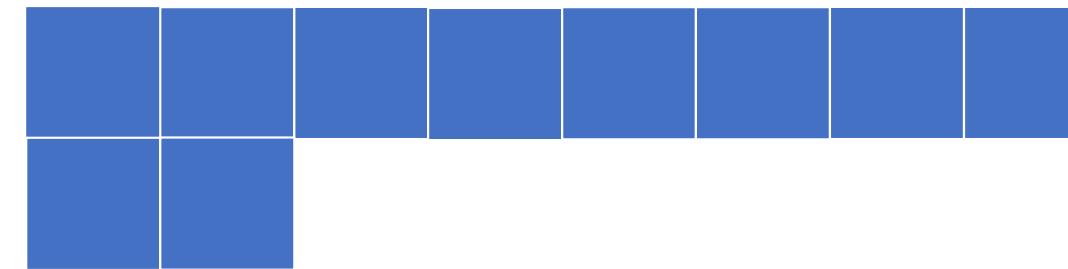


# Convolve Process

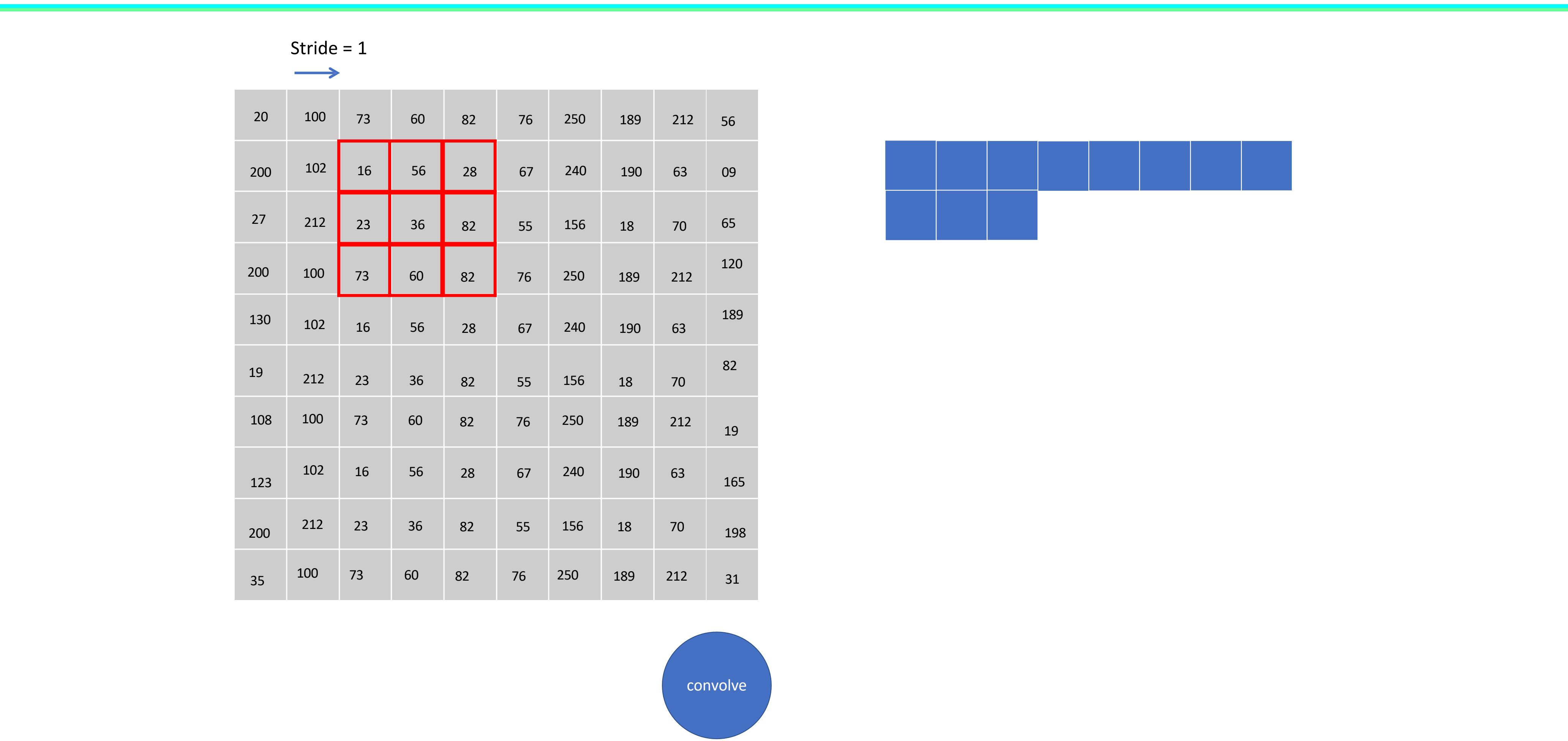
Stride = 1



20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

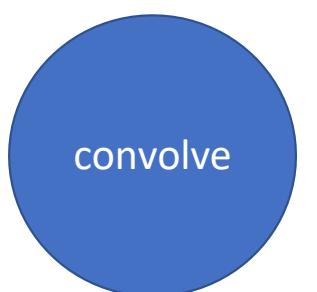
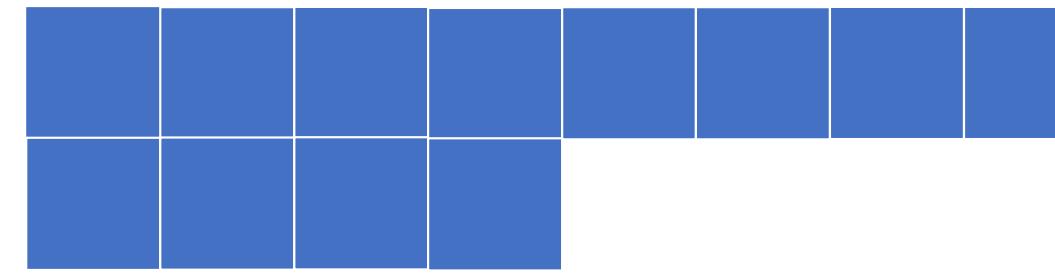


# Convolve Process

Stride = 1



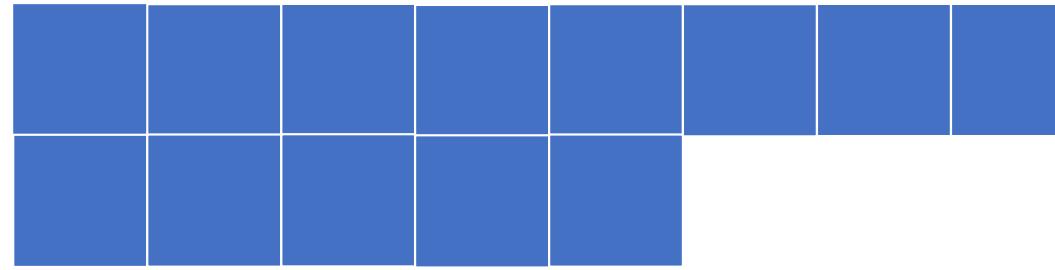
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

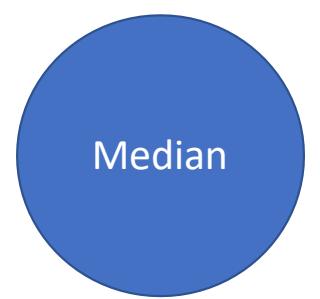
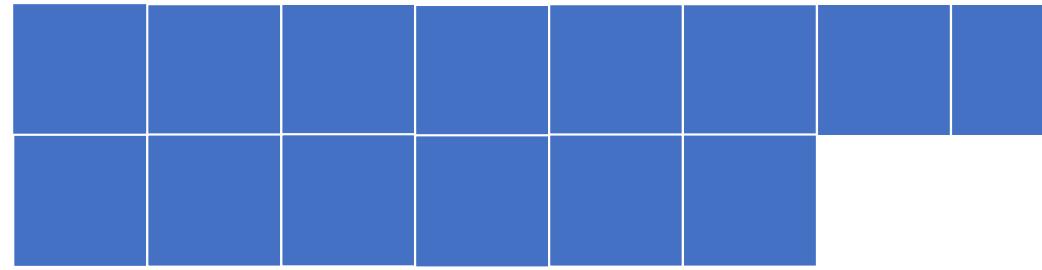


# Convolve Process

Stride = 1

→

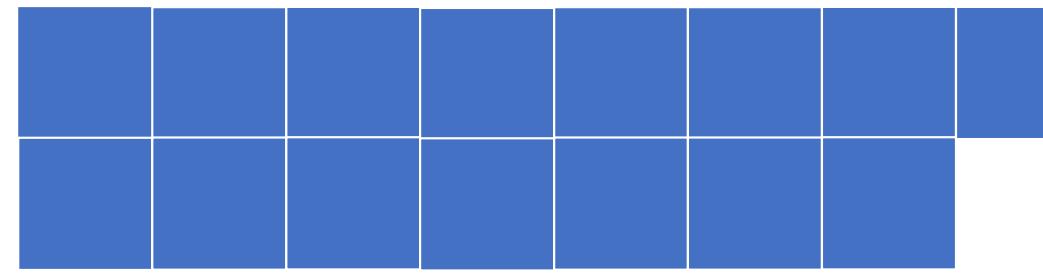
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

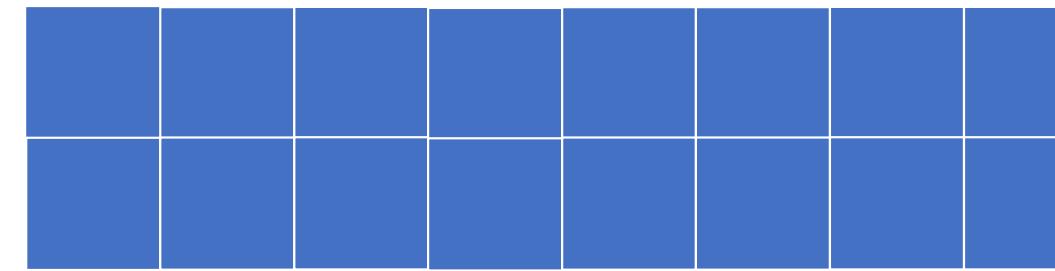
20	100	73	60	82	76	250	189	212	56	
200	102	16	56	28	67	240	190	63	09	
27	212	23	36	82	55	156	18	70	65	
200	100	73	60	82	76	250	189	212	120	
130	102	16	56	28	67	240	190	63	189	
19	212	23	36	82	55	156	18	70	82	
108	100	73	60	82	76	250	189	212	19	
123	102	16	56	28	67	240	190	63	165	
200	212	23	36	82	55	156	18	70	198	
35	100	73	60	82	76	250	189	212	31	



# Convolve Process

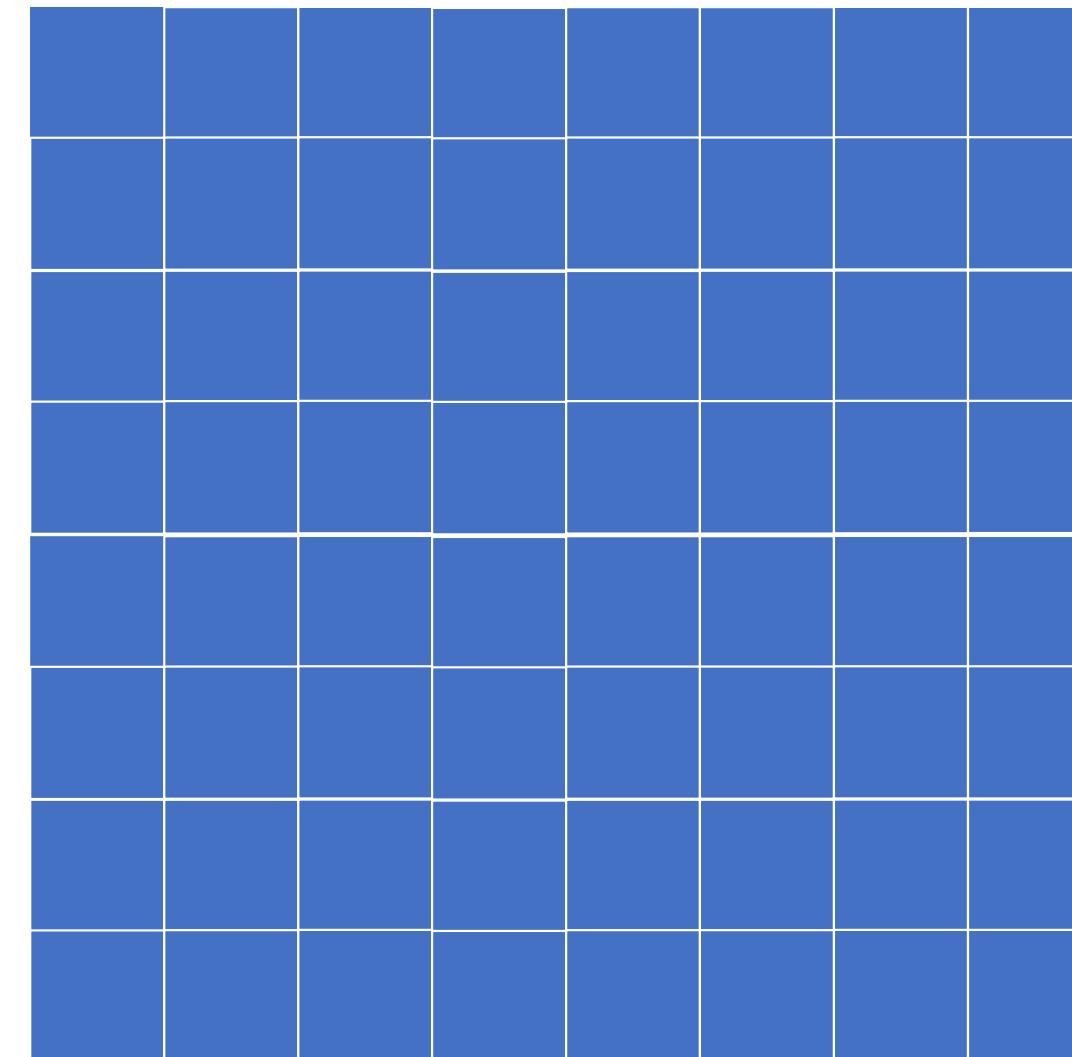
Stride = 1  
→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



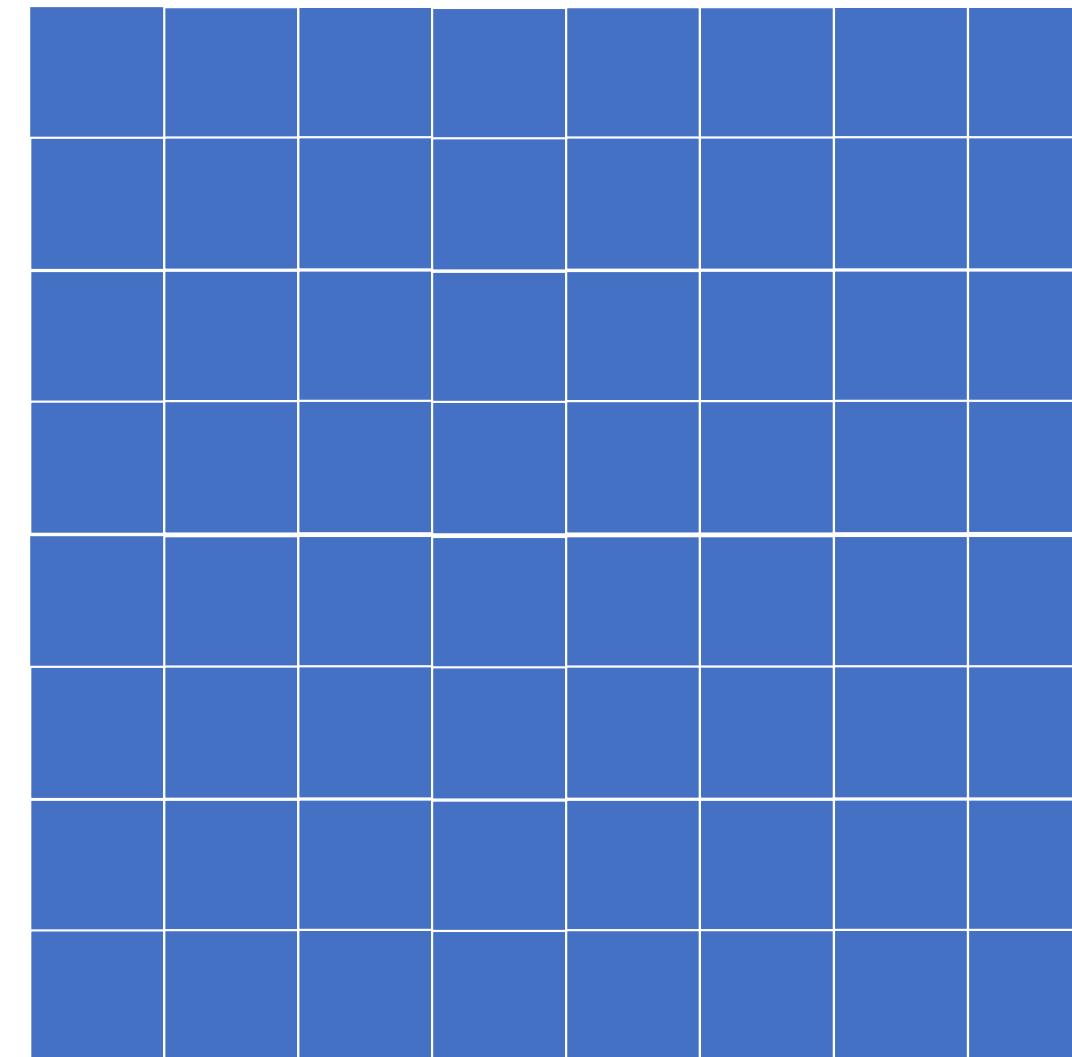
# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

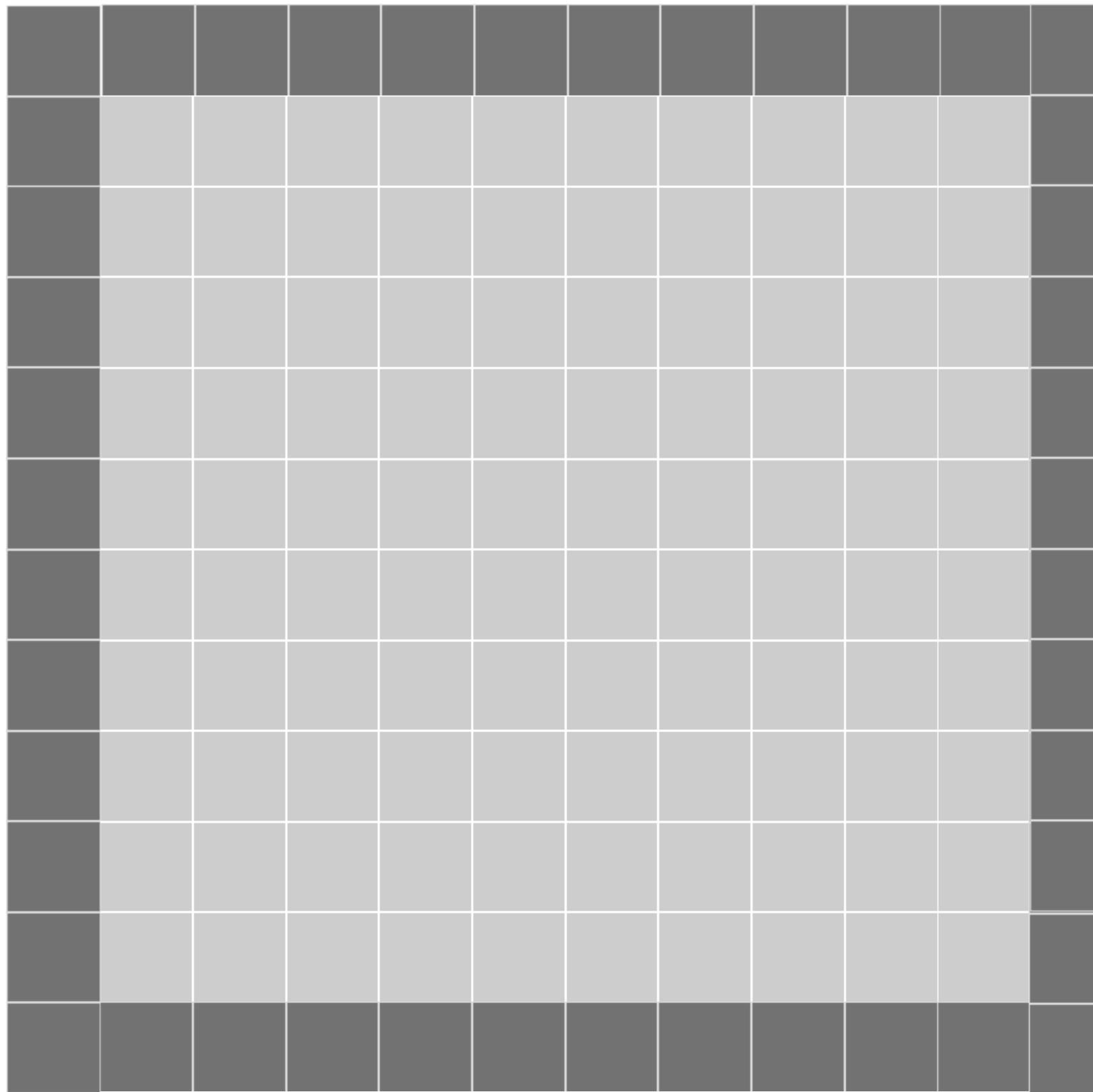


# Convolve Process

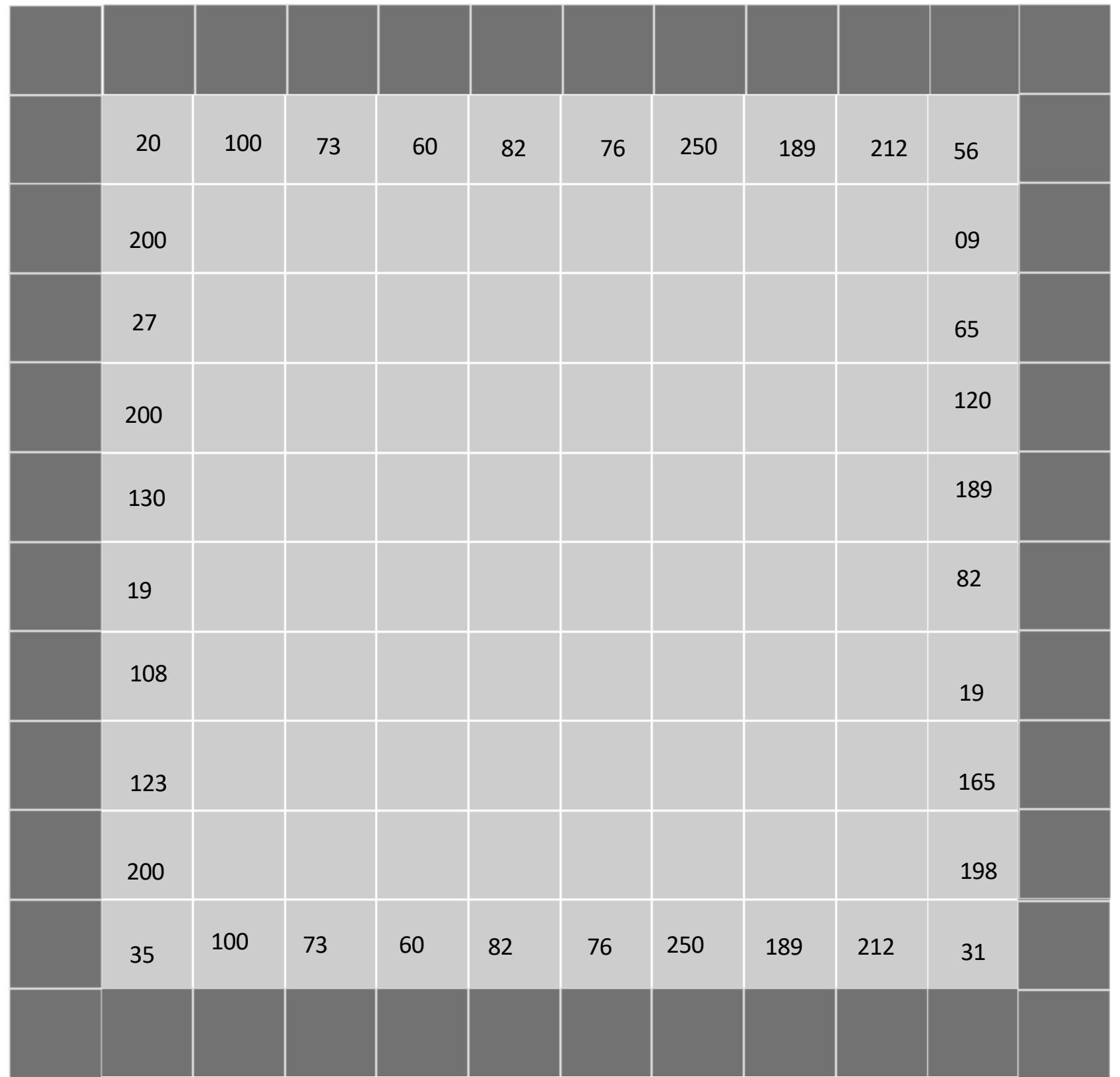
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Padding to Retain the W & H

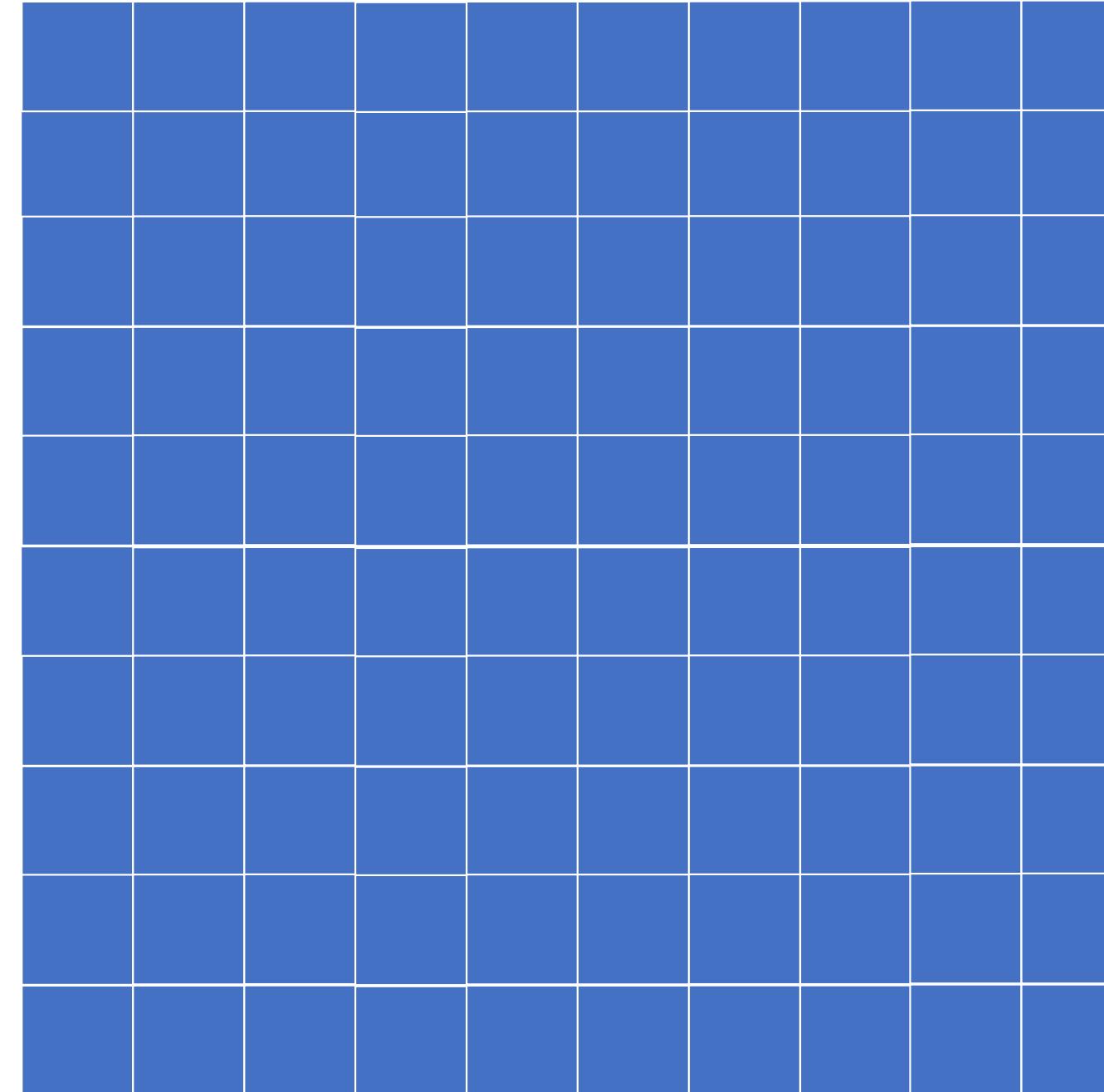
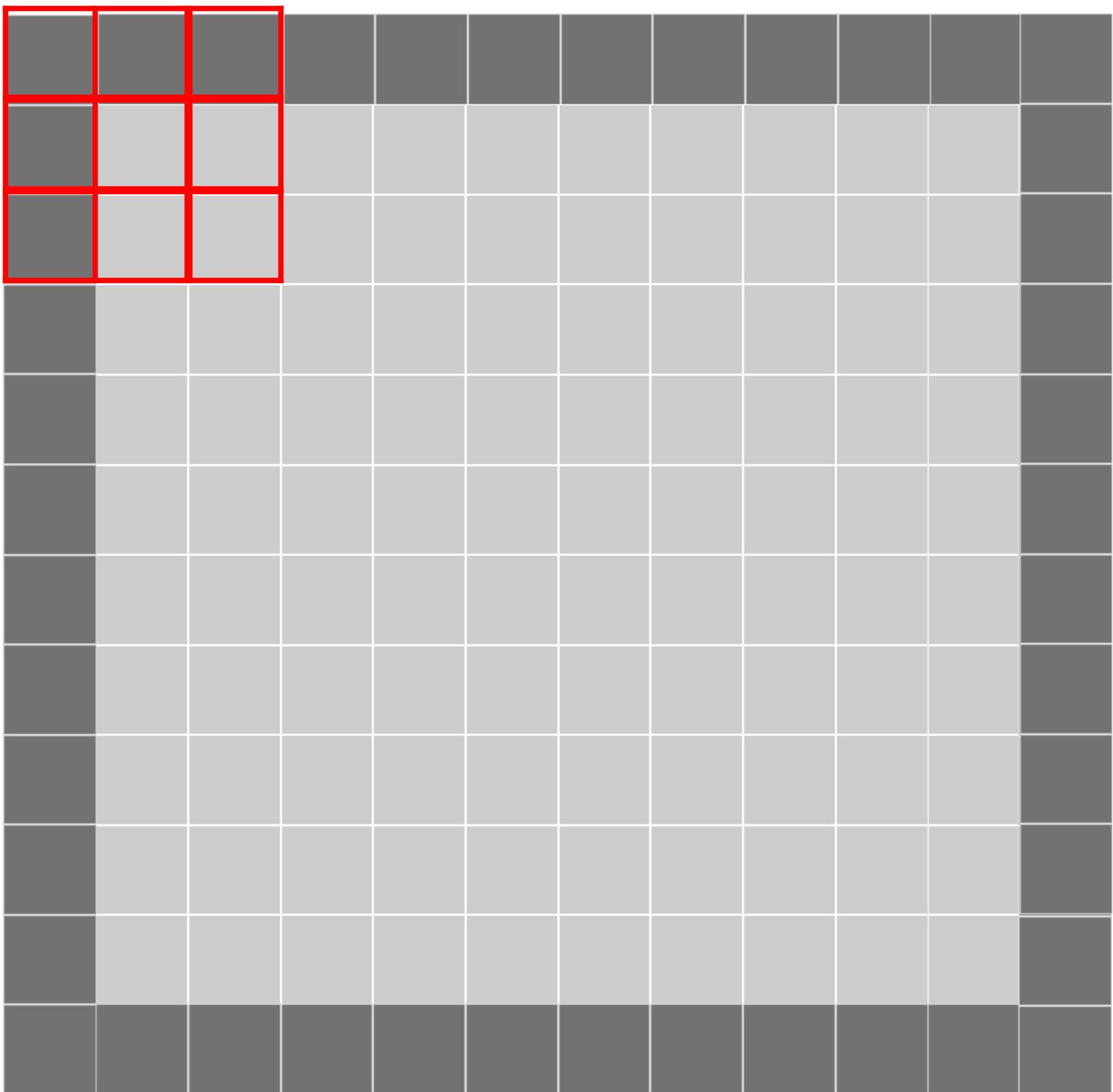


# Same Padding



# Same Padding or Zero Padding

# Apply Convolve



convolve

# Gaussian Blur in OpenCV

```
cv2.GaussianBlur(src,ksize)
```

# **Median Blur**

**Smoothing Filter**

# Median Blur

---

- Step-1: Define  $k \times k$  sliding window on top of the image.
  - $k$  is always odd number
- Step-2: Slide the window from left to right and top to bottom
- Step-3: For each stride (usually stride = 1), pixel at the center of the matrix is **Median** of pixels surrounding it.

# Median Blur

---

- Median blurring is more effective at removing *salt and pepper style noise* from the image.

# Median Blur for Salt-Pepper Noise

---



# Median Blur (3 x 3)

---



# Median Blur (5 x 5)

---



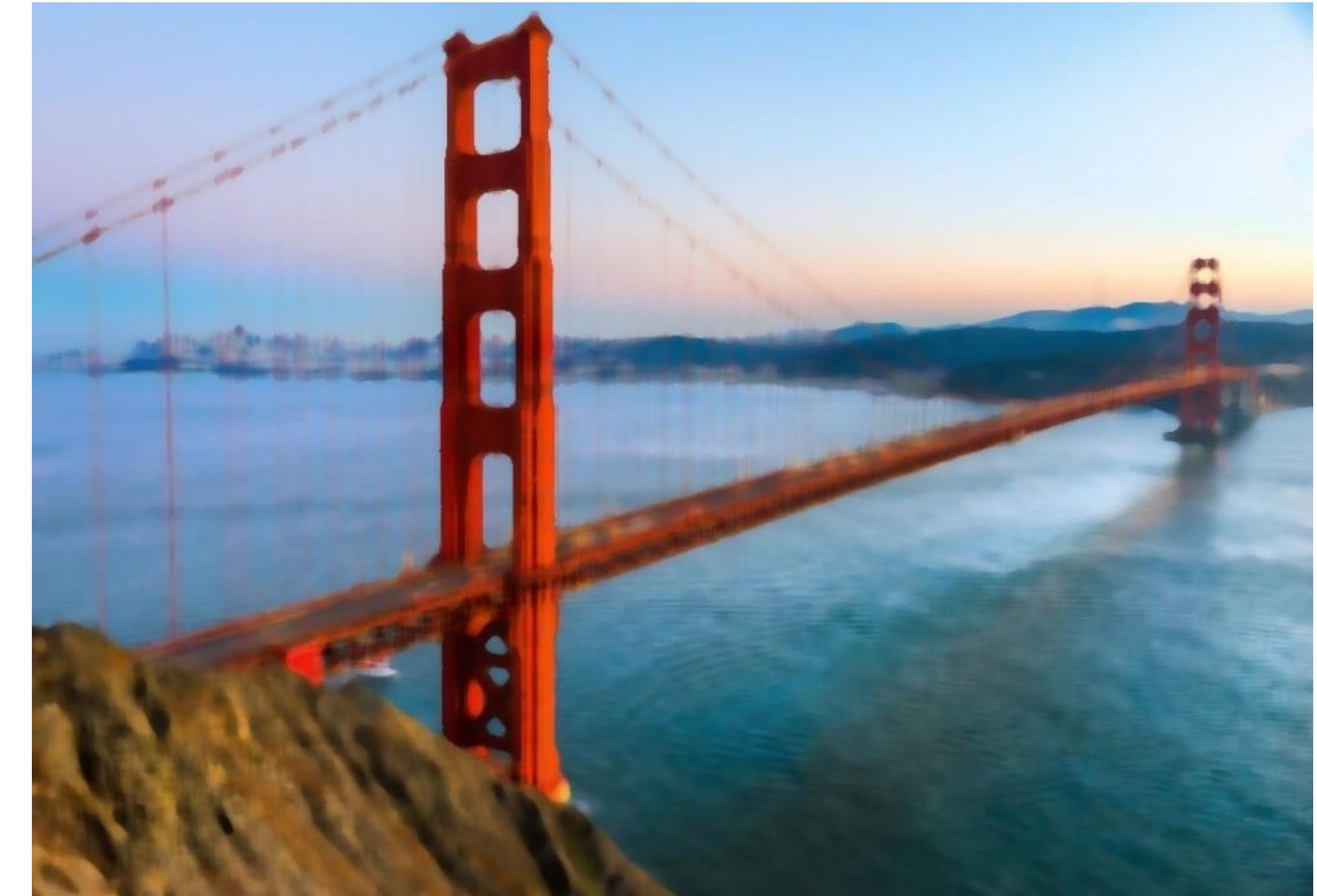
# Median Blur (7 x 7)

---



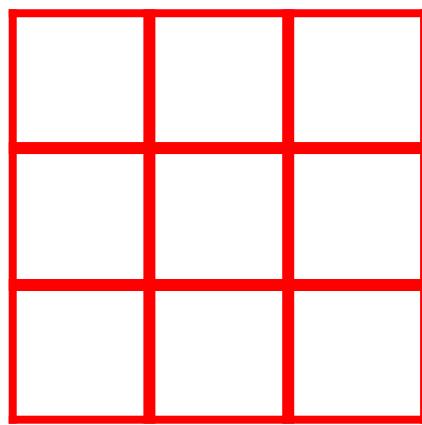
# Median Blur (11 x 11)

---

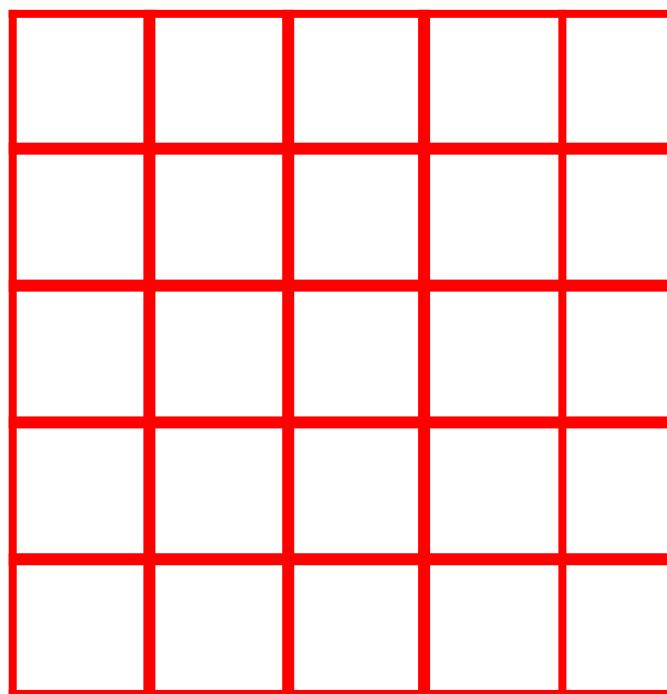


# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



3 × 3



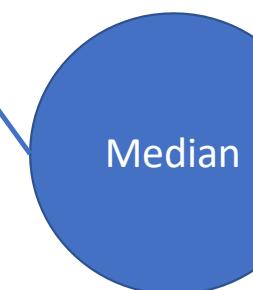
5 × 5

# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



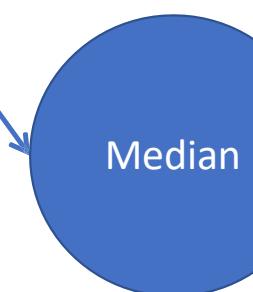
(16,20,23,27,**73**,100,102,200,212)= 73



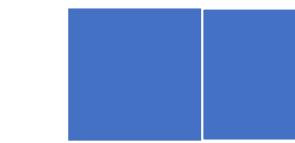
# Convolve Process

Stride = 1

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



$$(16, 23, 36, 56, \textcolor{red}{60}, 73, 100, 102, 212) = 60$$

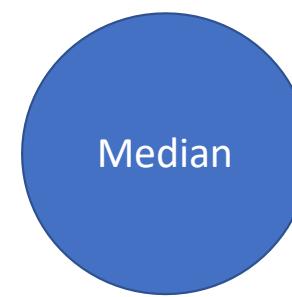
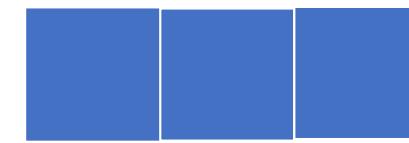


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

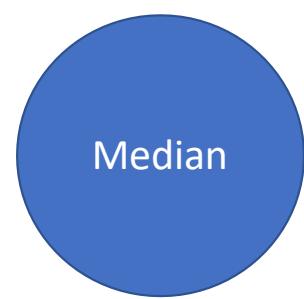
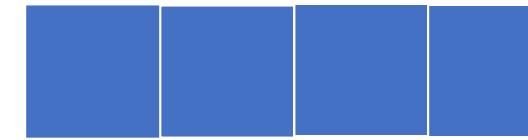


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

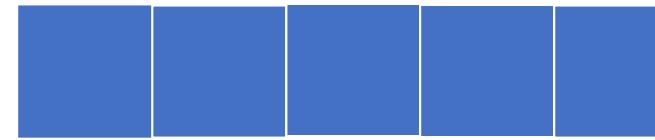


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

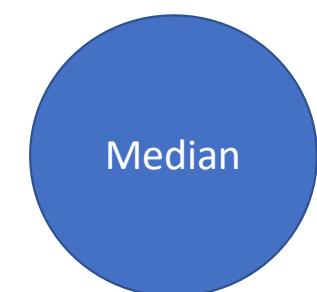


# Convolve Process

Stride = 1

→

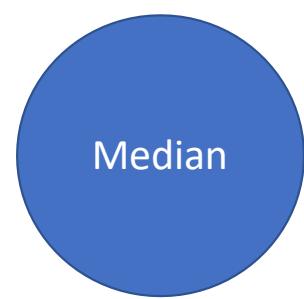
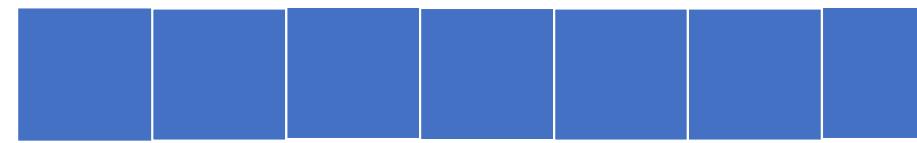
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

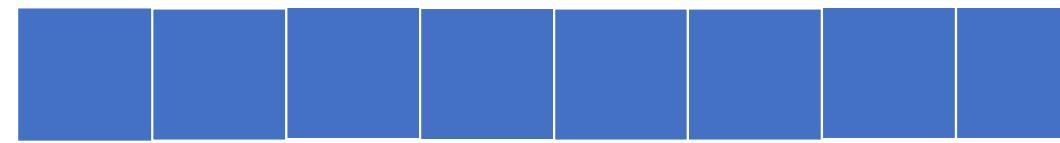
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

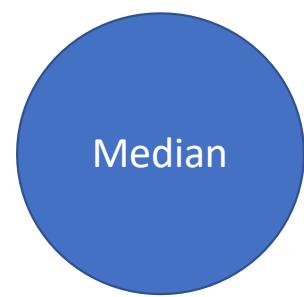
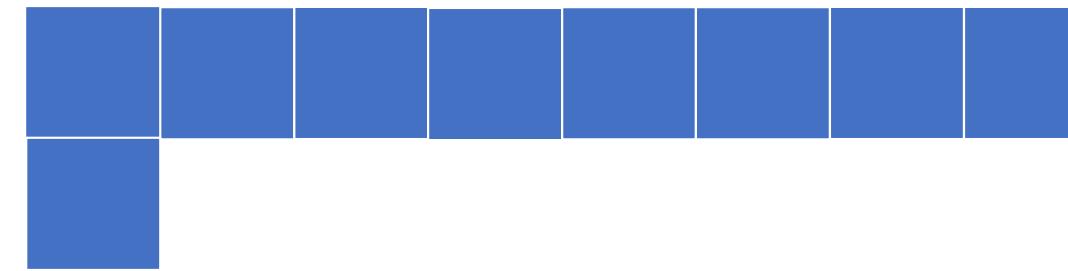
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

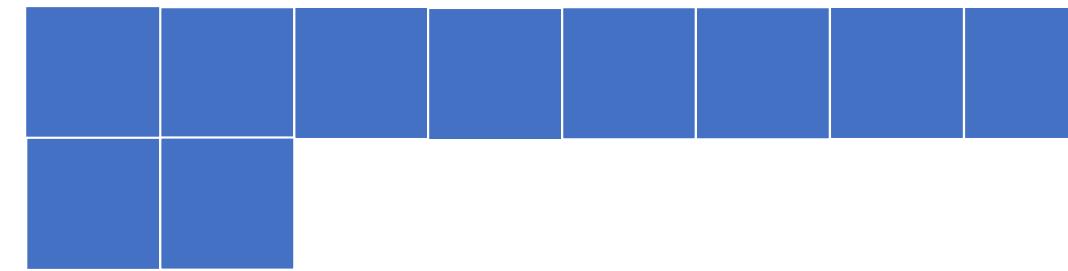


# Convolve Process

Stride = 1



20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

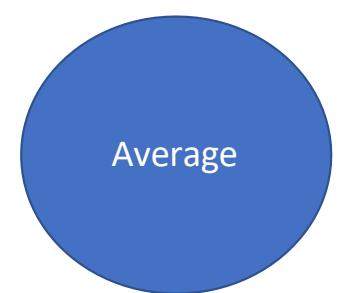
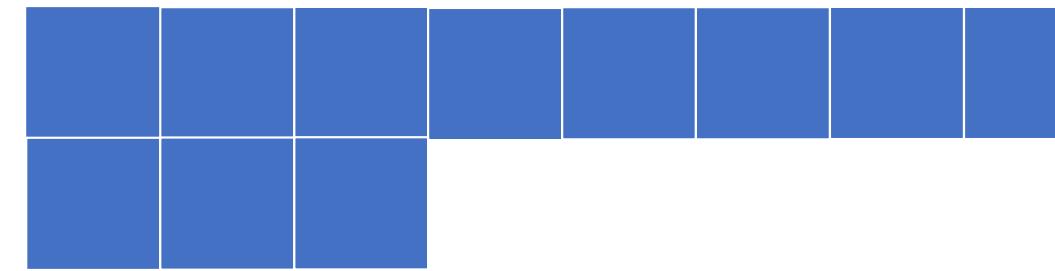


# Convolve Process

Stride = 1

→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

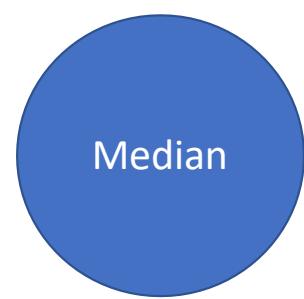
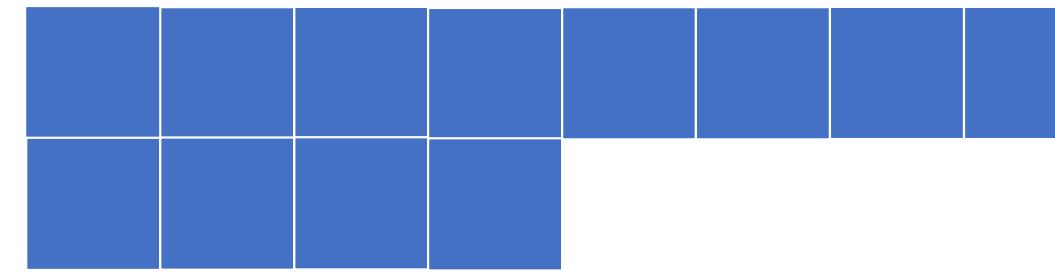


# Convolve Process

Stride = 1

→

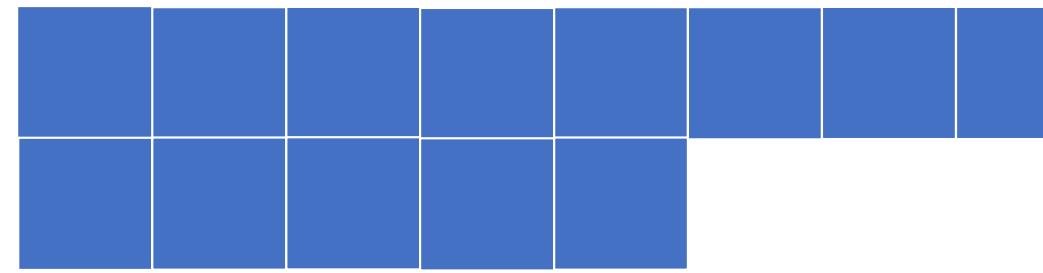
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

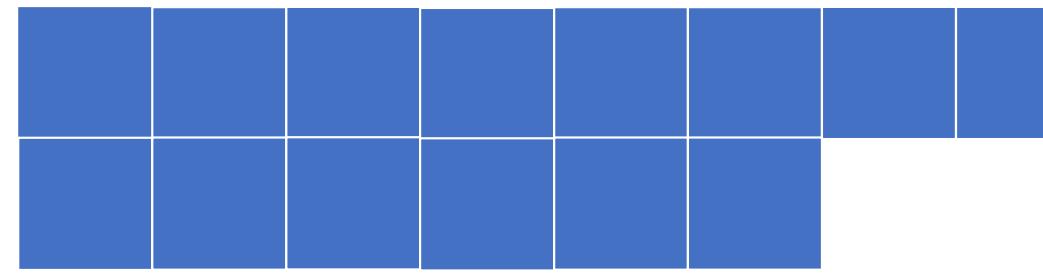


# Convolve Process

Stride = 1

→

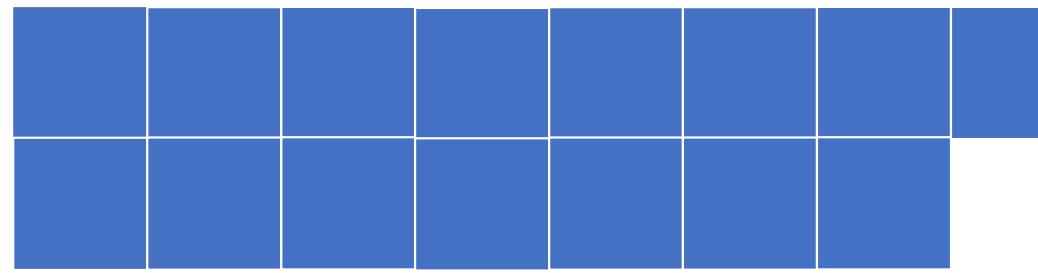
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Convolve Process

Stride = 1  
→

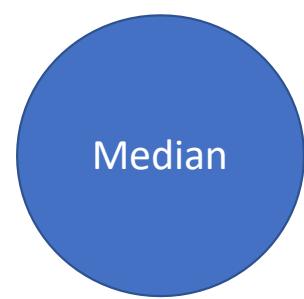
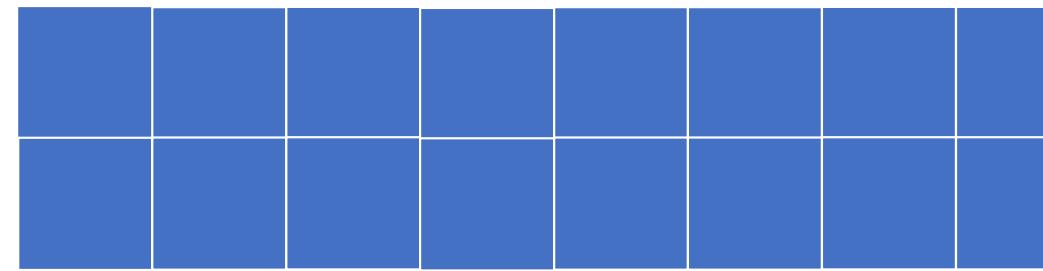
20	100	73	60	82	76	250	189	212	56	
200	102	16	56	28	67	240	190	63	09	
27	212	23	36	82	55	156	18	70	65	
200	100	73	60	82	76	250	189	212	120	
130	102	16	56	28	67	240	190	63	189	
19	212	23	36	82	55	156	18	70	82	
108	100	73	60	82	76	250	189	212	19	
123	102	16	56	28	67	240	190	63	165	
200	212	23	36	82	55	156	18	70	198	
35	100	73	60	82	76	250	189	212	31	



# Convolve Process

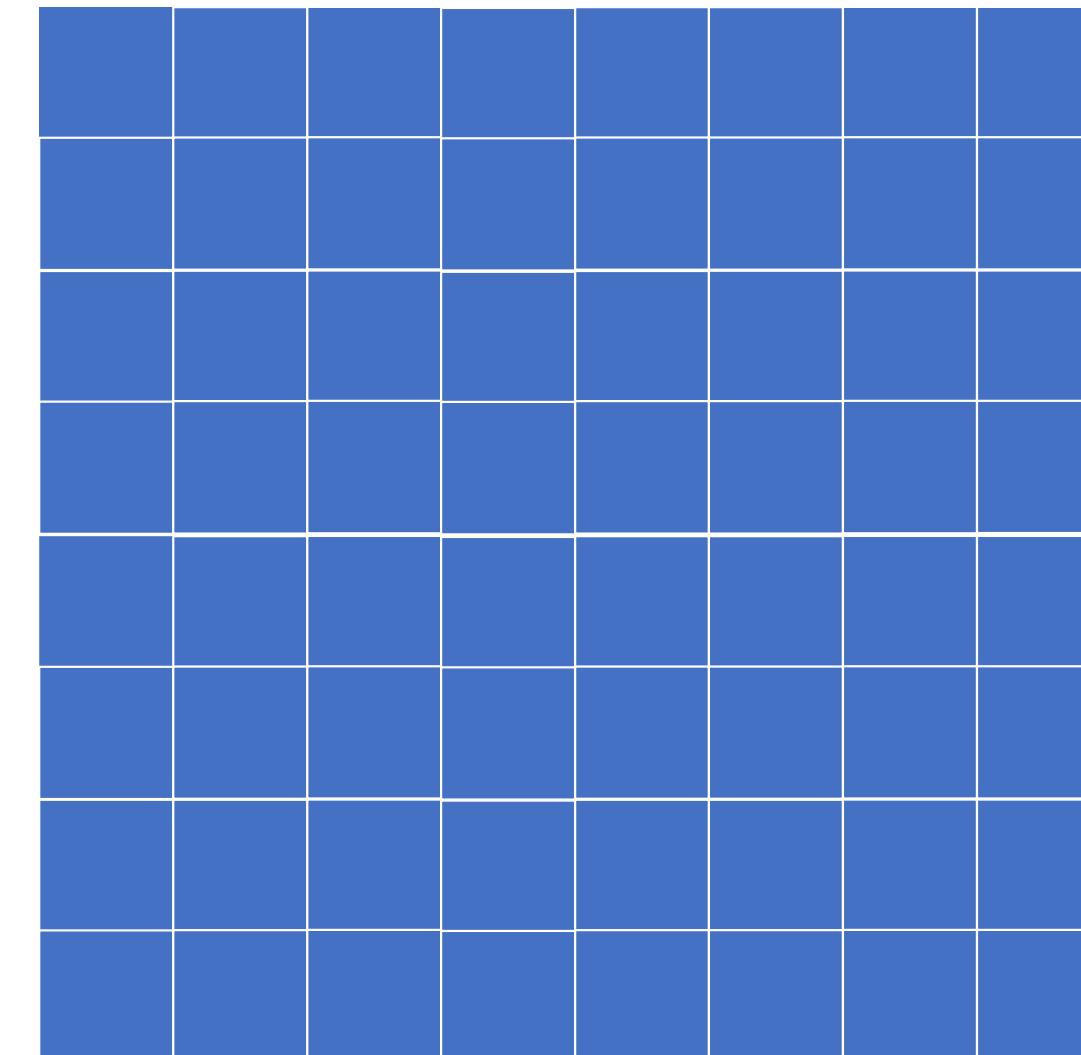
Stride = 1  
→

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



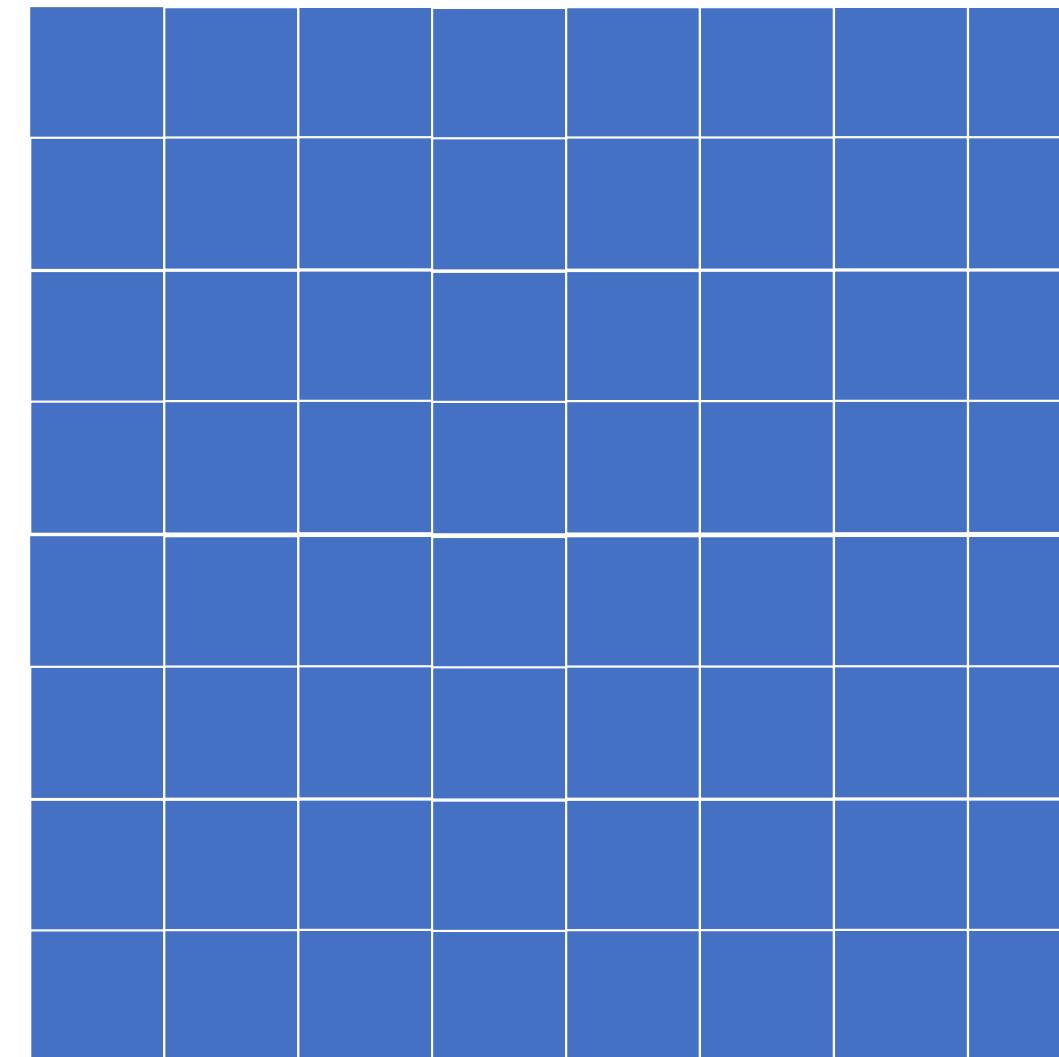
# Convolve Process

20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31

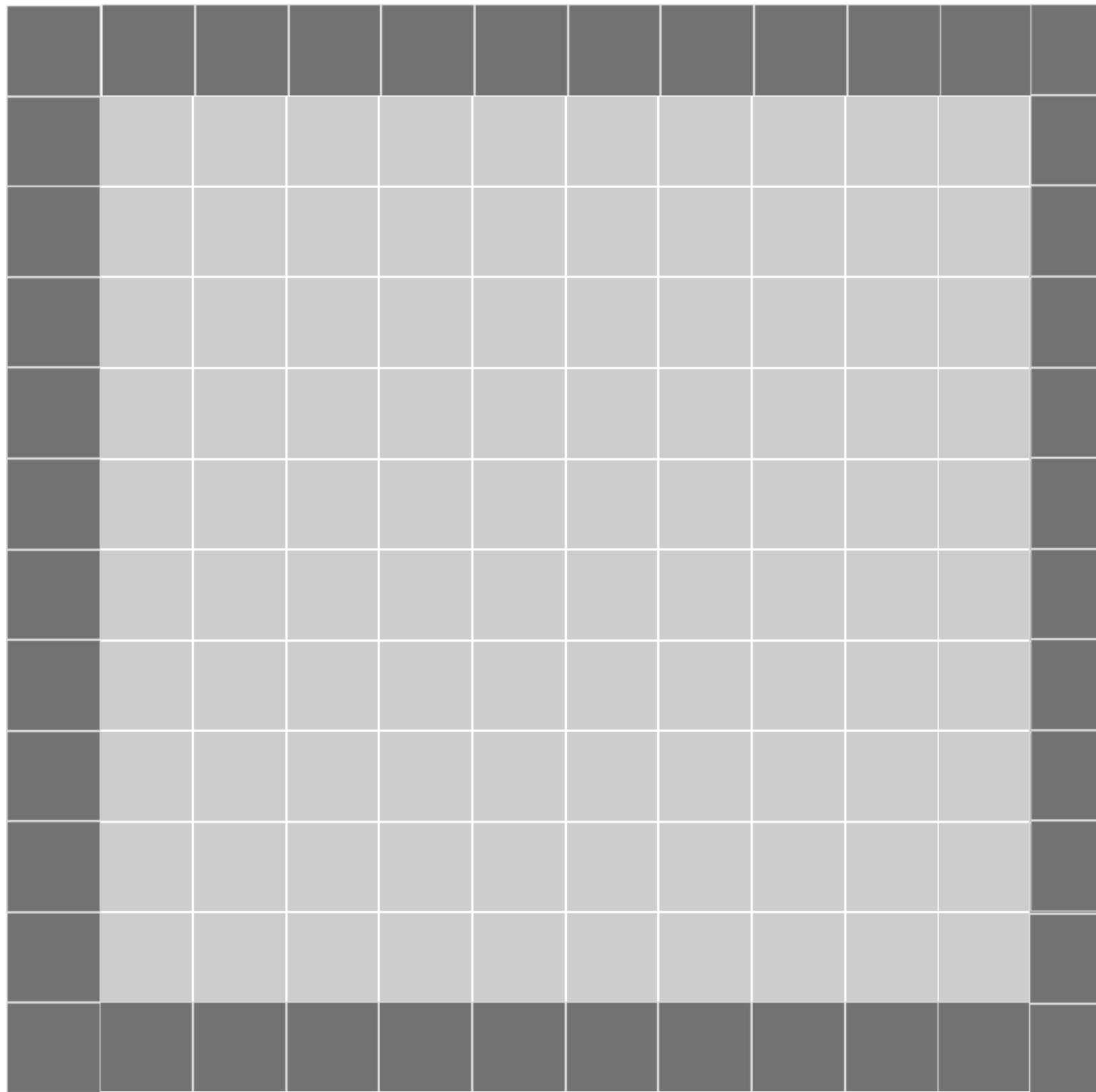


# Convolve Process

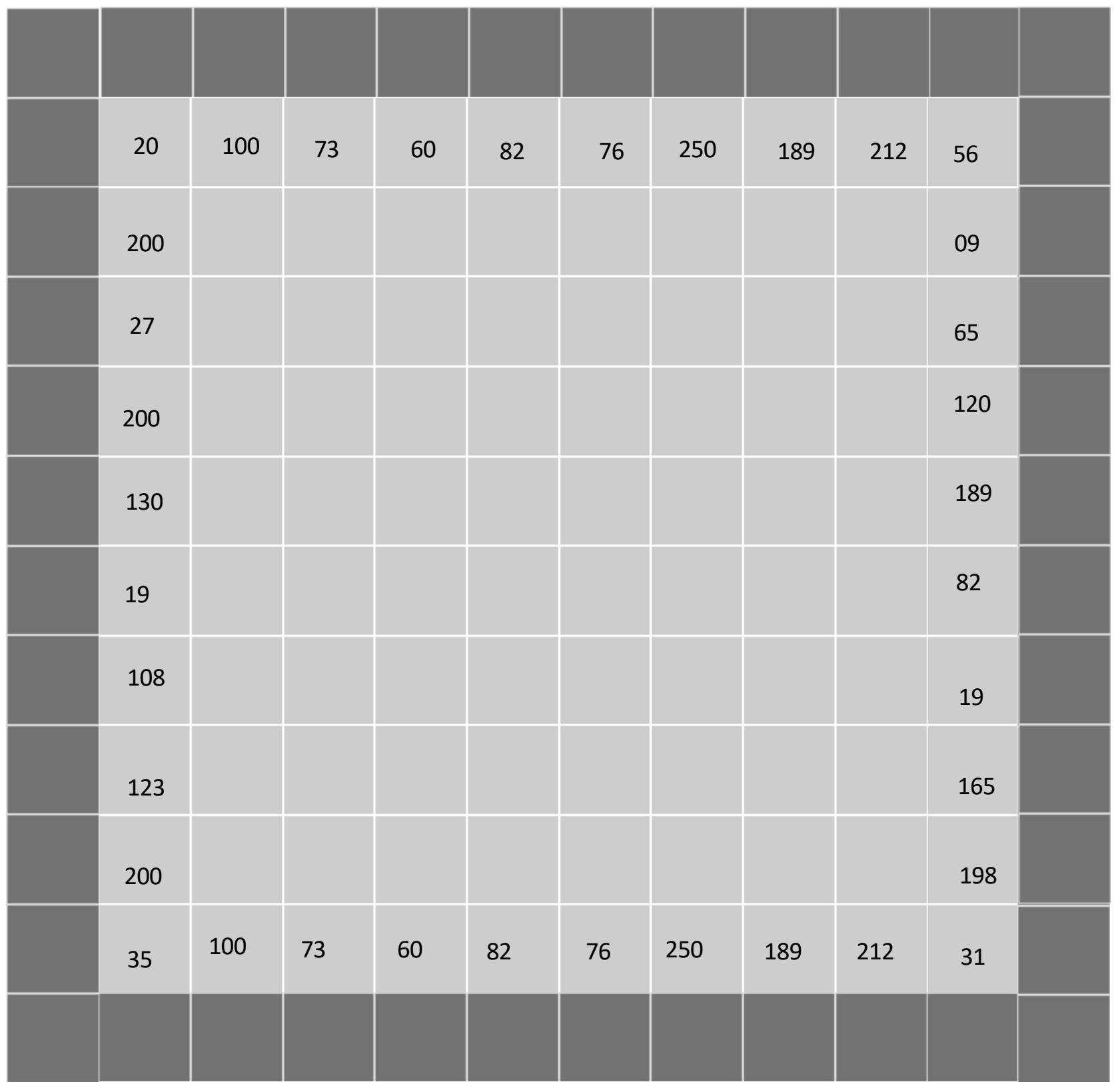
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70	198
35	100	73	60	82	76	250	189	212	31



# Padding to Retain the W & H

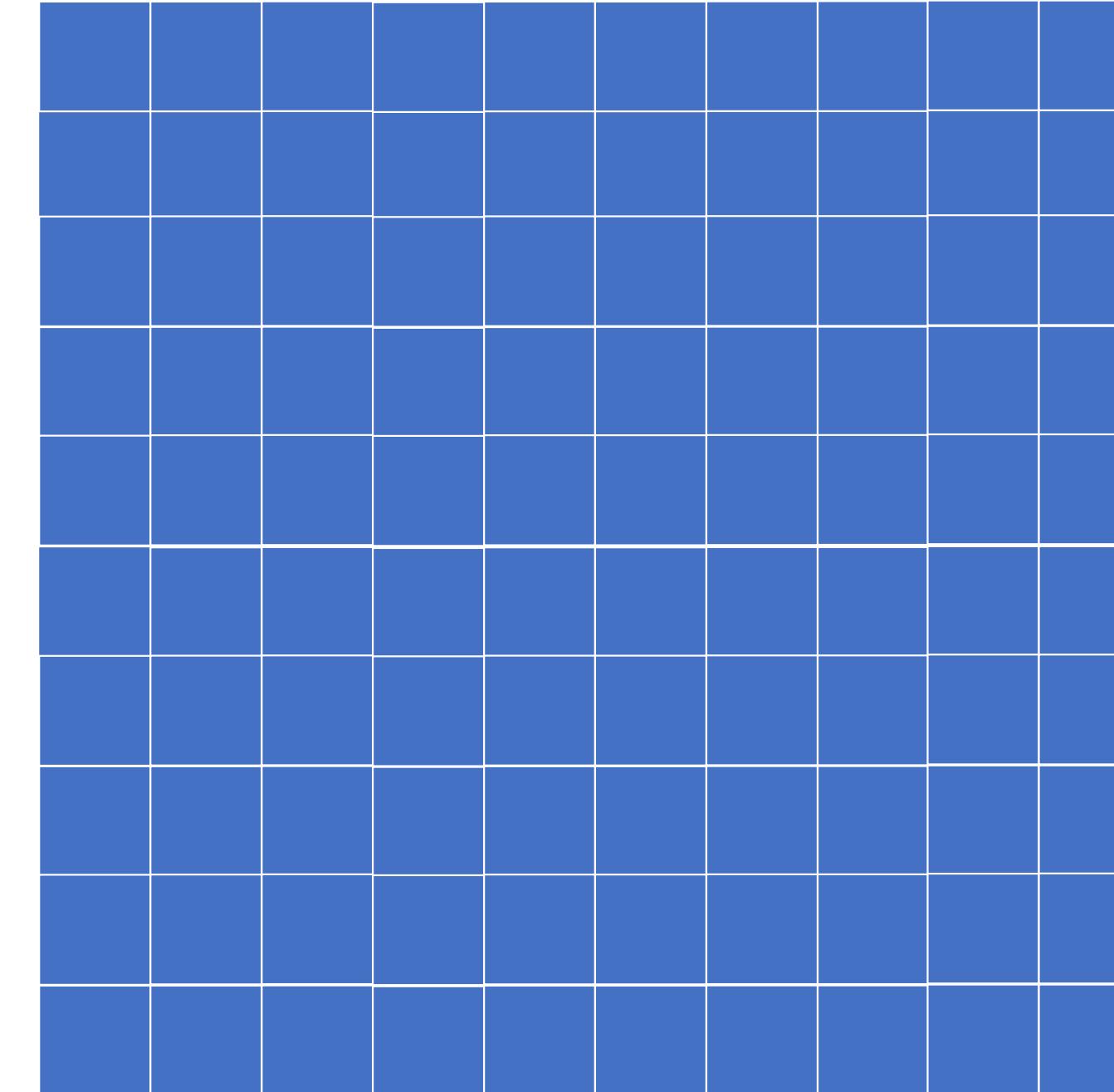
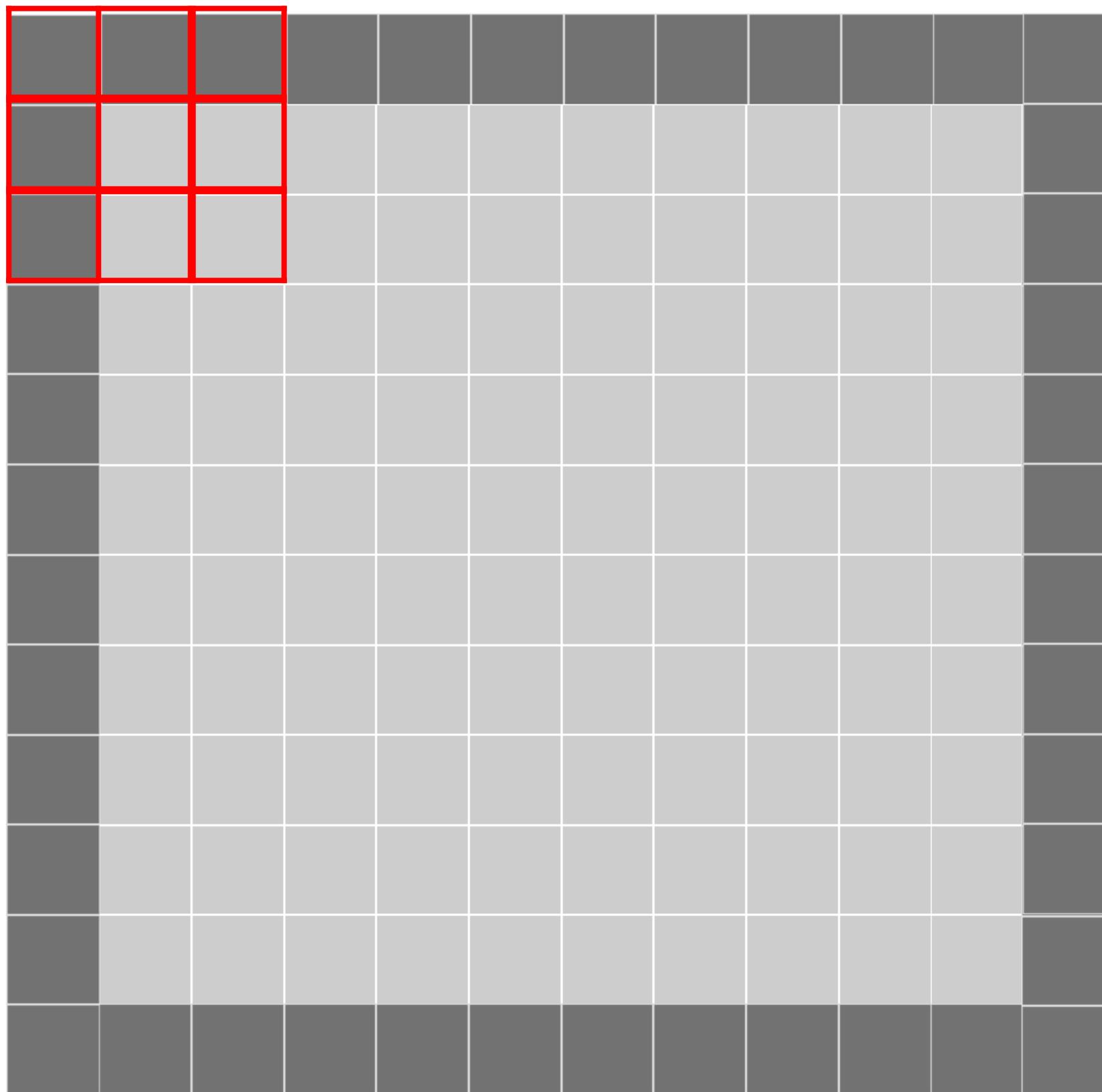


# Same Padding



# Same Padding or Zero Padding

# Apply Convolve



Median

# Median Blur in OpenCV

---

```
cv2.medianblur(src,ksize)
```