Smoothing Filters

Blurring

Gaussian Blur

Smoothing Filter

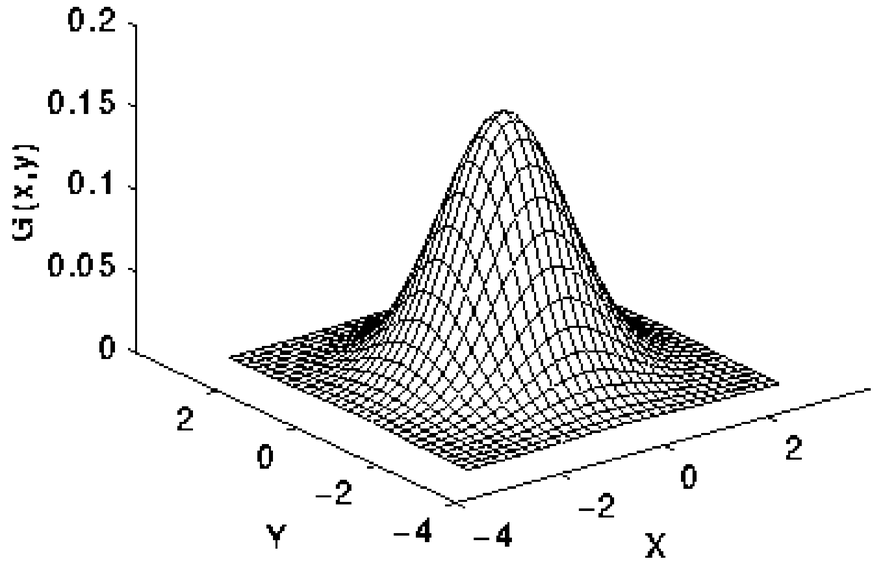
Gaussian Blur

- 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 x 3 →

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

5 x 5 →

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

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

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

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

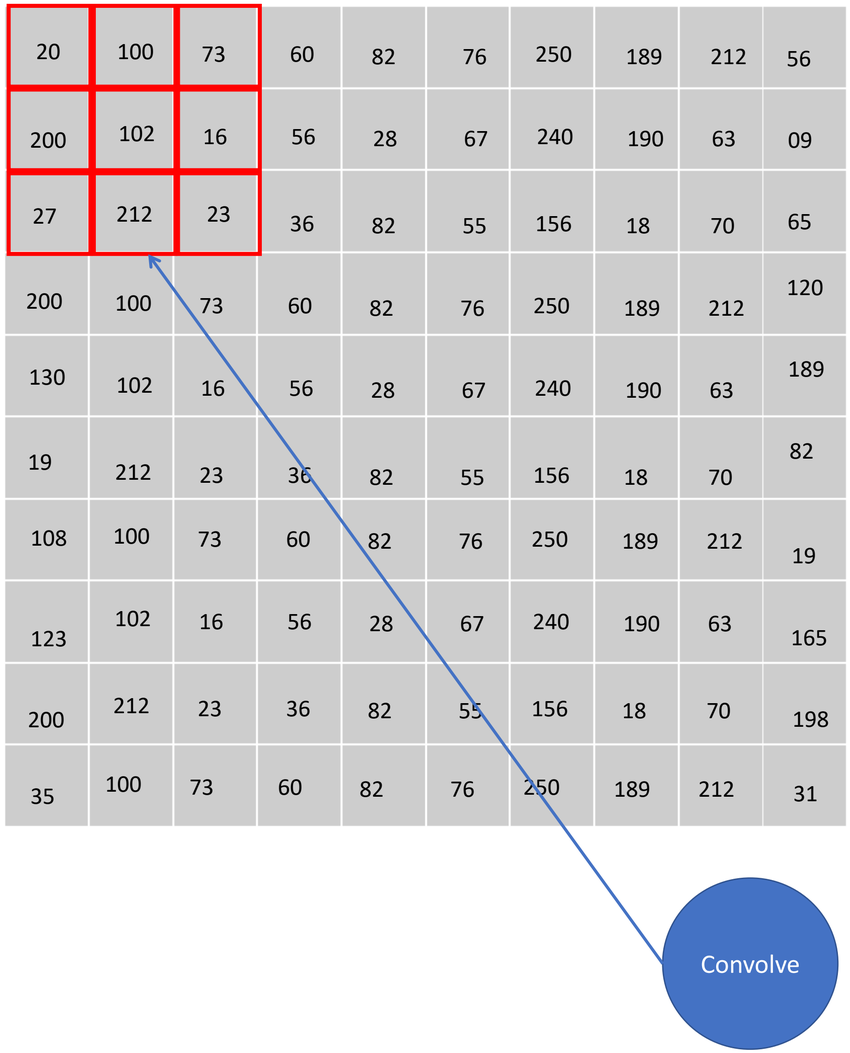
Convolve Process

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

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



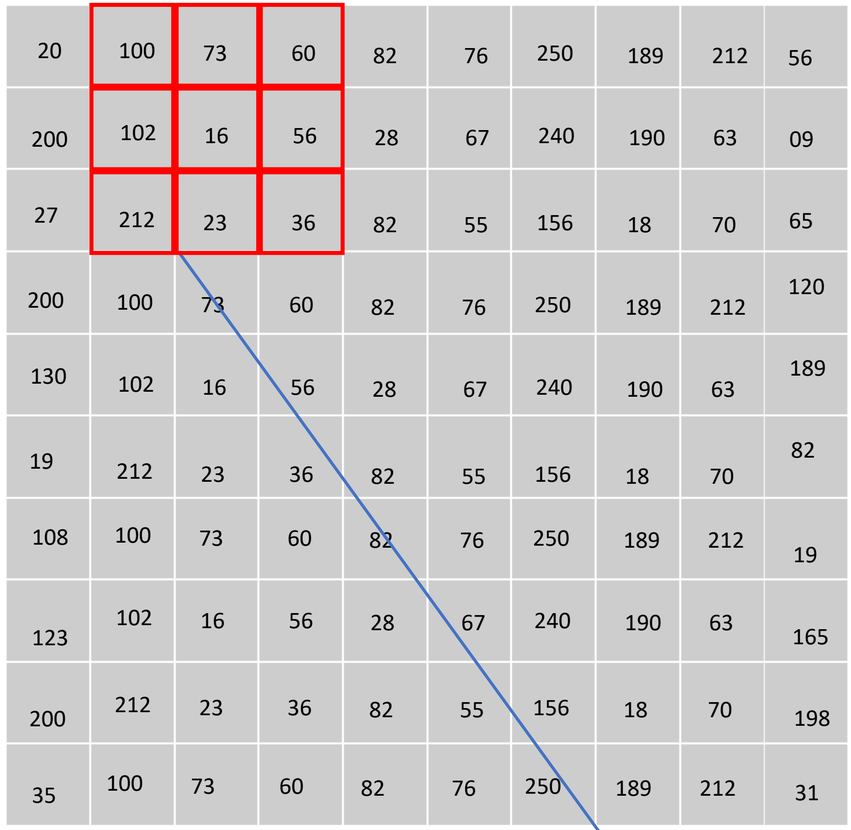
$$\begin{bmatrix} 20 & 100 & 73 \\ 200 & 102 & 16 \\ 27 & 212 & 23 \end{bmatrix} * \frac{1}{16}\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

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

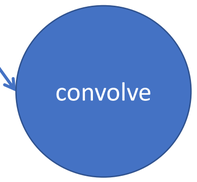
$$= 101$$

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

Median

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

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

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

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

Convolve Process

Stride = 1

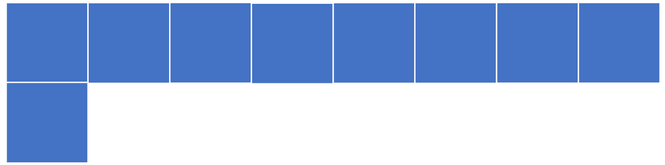
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70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

convolve

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

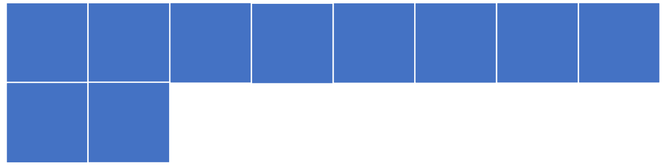


convolve

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

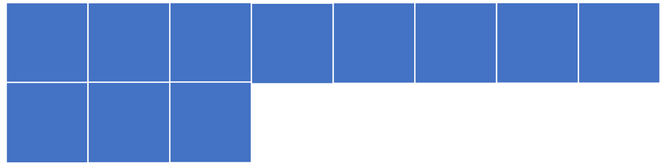


convolve

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

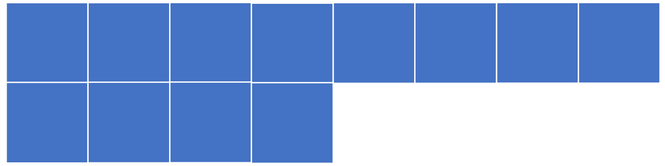


convolve

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

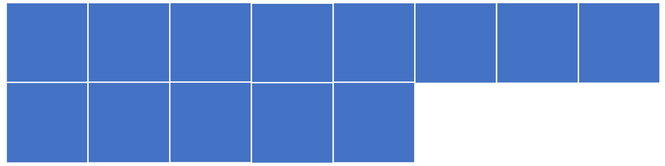


convolve

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

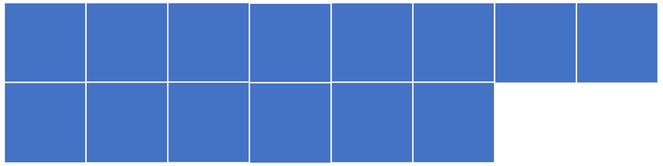


convolve

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

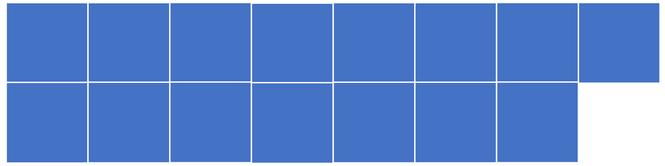


Median

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

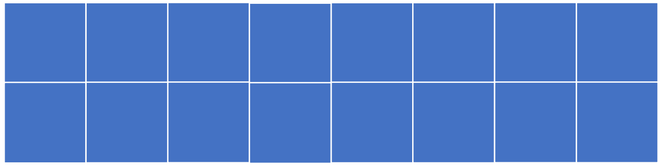


convolve

Convolve Process

Stride = 1

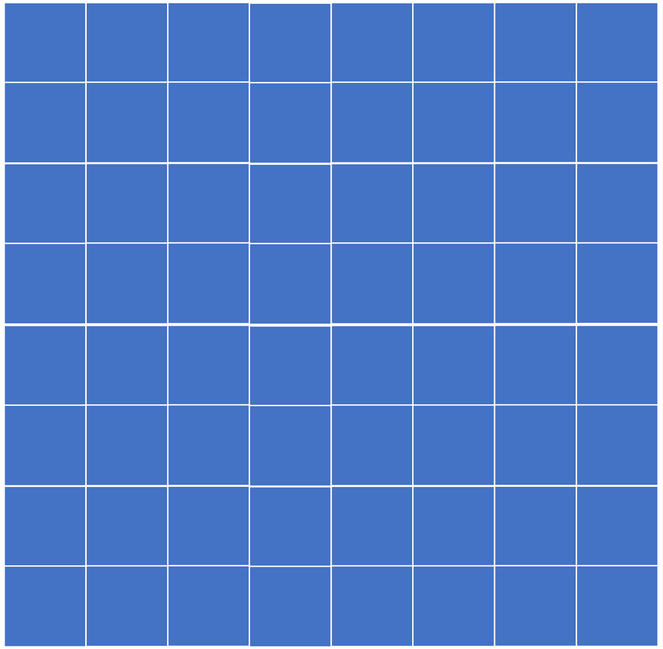
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70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



convolve

Convolve Process

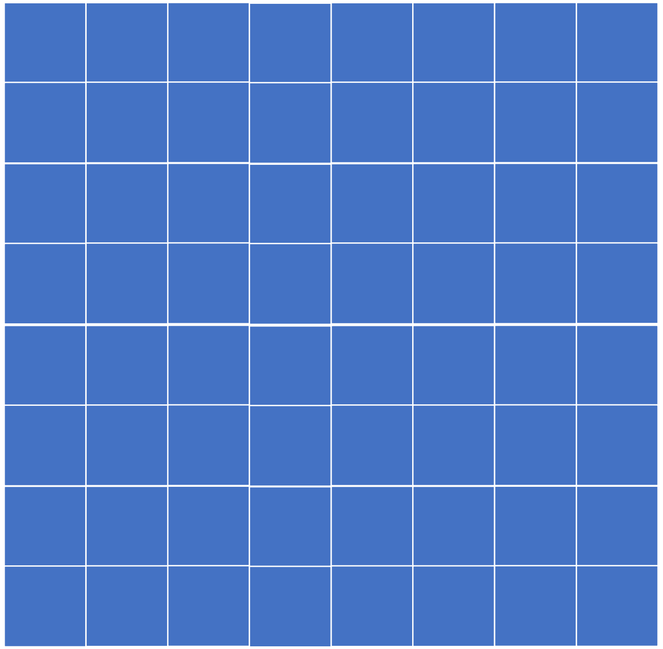
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70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



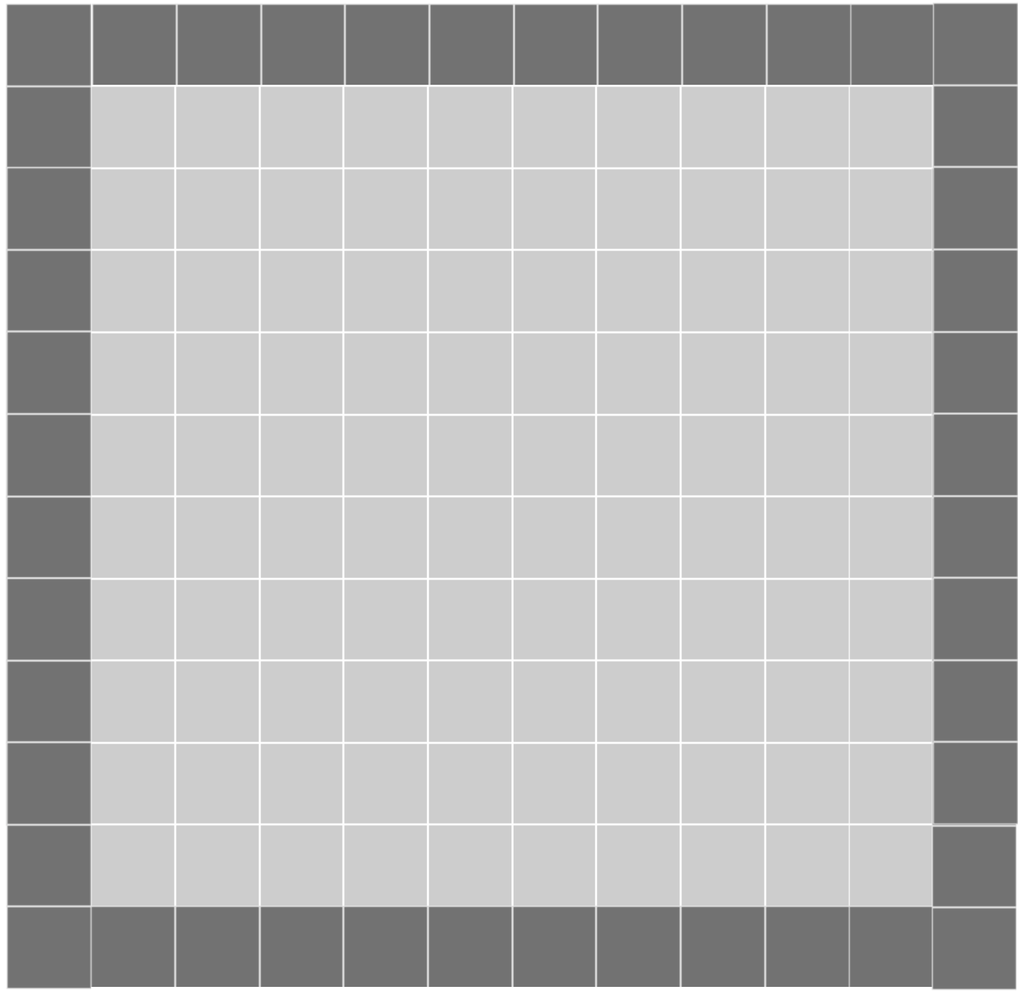
convolve

Convolve Process

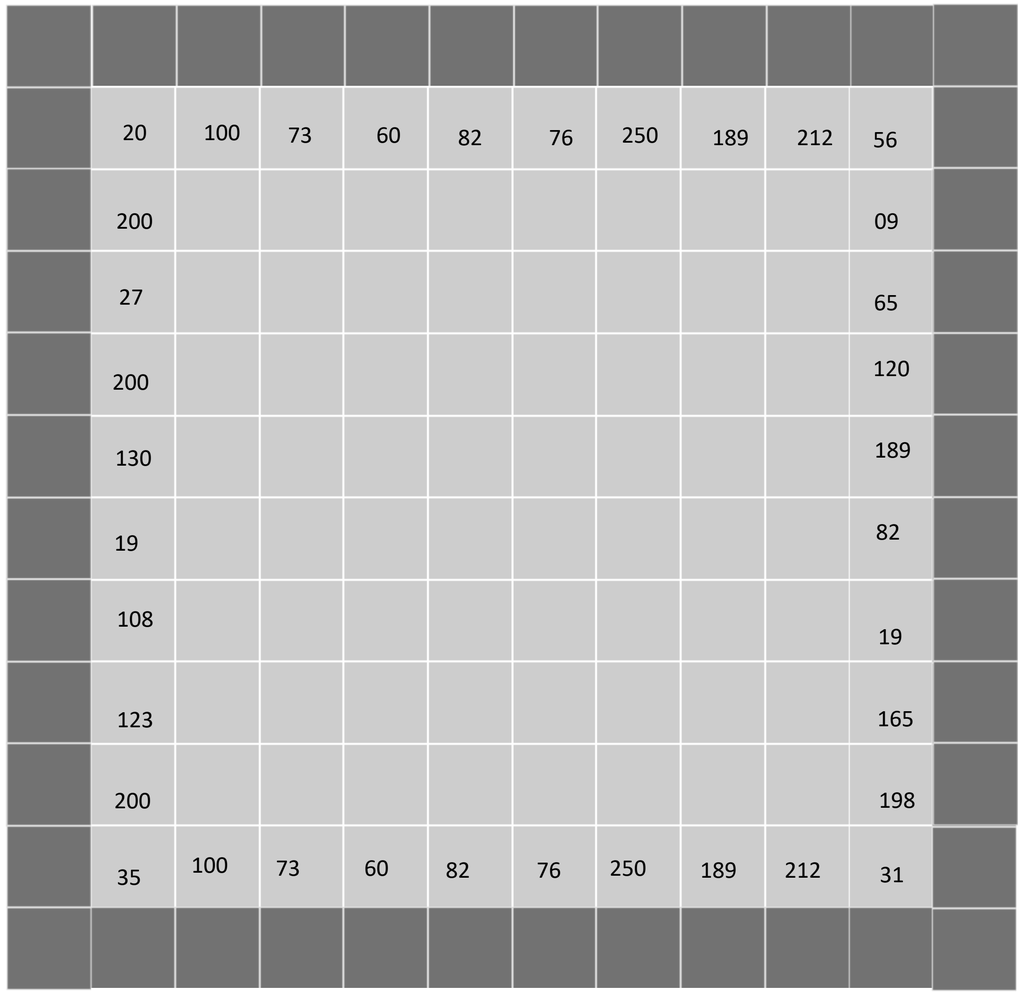
20	100	73	60	82	76	250	189	212	56
200	102	16	56	28	67	240	190	63	09
27	212	23	36	82	55	156	18	70	65
200	100	73	60	82	76	250	189	212	120
130	102	16	56	28	67	240	190	63	189
19	212	23	36	82	55	156	18	70	82
108	100	73	60	82	76	250	189	212	19
123	102	16	56	28	67	240	190	63	165
200	212	23	36	82	55	156	18	70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



Padding to Retail the W & H



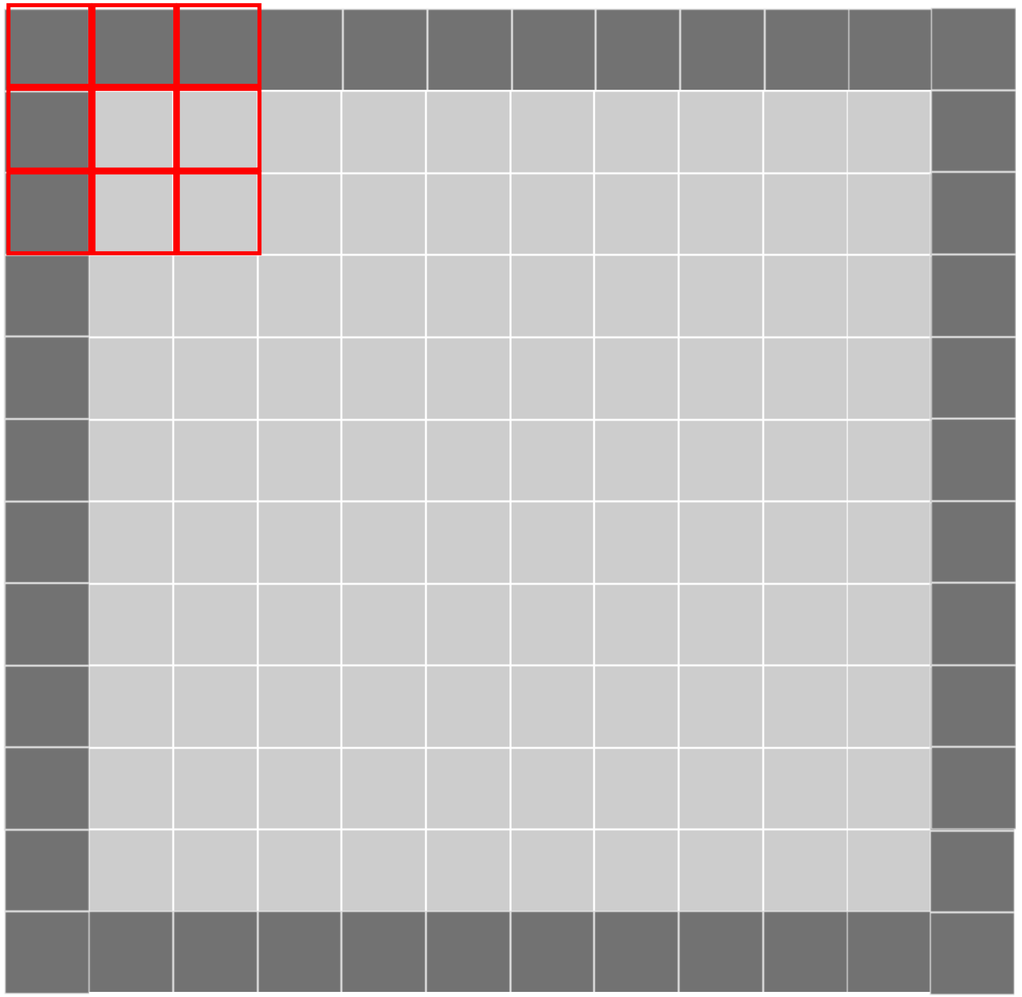
Same Padding



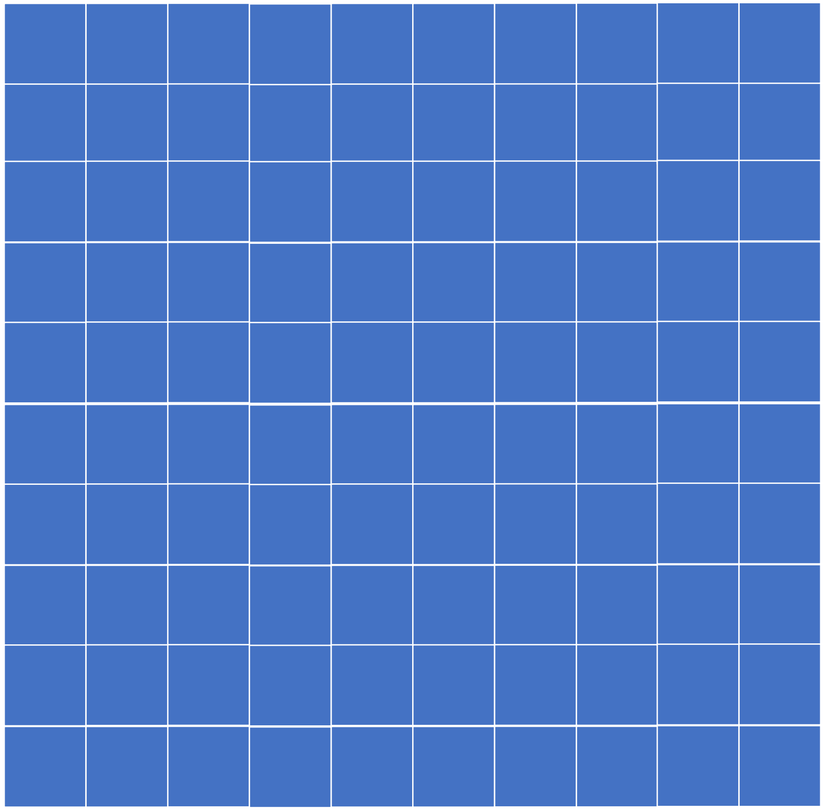
Same Padding or Zero Padding

0	0	0	0	0	0	0	0	0	0	0	0
0	20	100	73	60	82	76	250	189	212	56	0
0	200									09	0
0	27									65	0
0	200									120	0
0	130									189	0
0	19									82	0
0	108									19	0
0	123									165	0
0	200									198	0
0	35	100	73	60	82	76	250	189	212	31	0
0	0	0	0	0	0	0	0	0	0	0	0

Apply Convolve



convolve



Gaussian Blur in OpenCV

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

Next

Gaussian Blur in **OpenCV Python**