Sane's STATS Academy of Statistics

Convolution Concept

By Example

Digit Image

- Consider a 9 x 9 pixel image
- Black and White
- Containing only 1s and 0s

0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	0	0
0	0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0	0
0	0	0	0	1	1	0	0	0
0	0	0	1	1	0	0	0	0
0	0	1	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

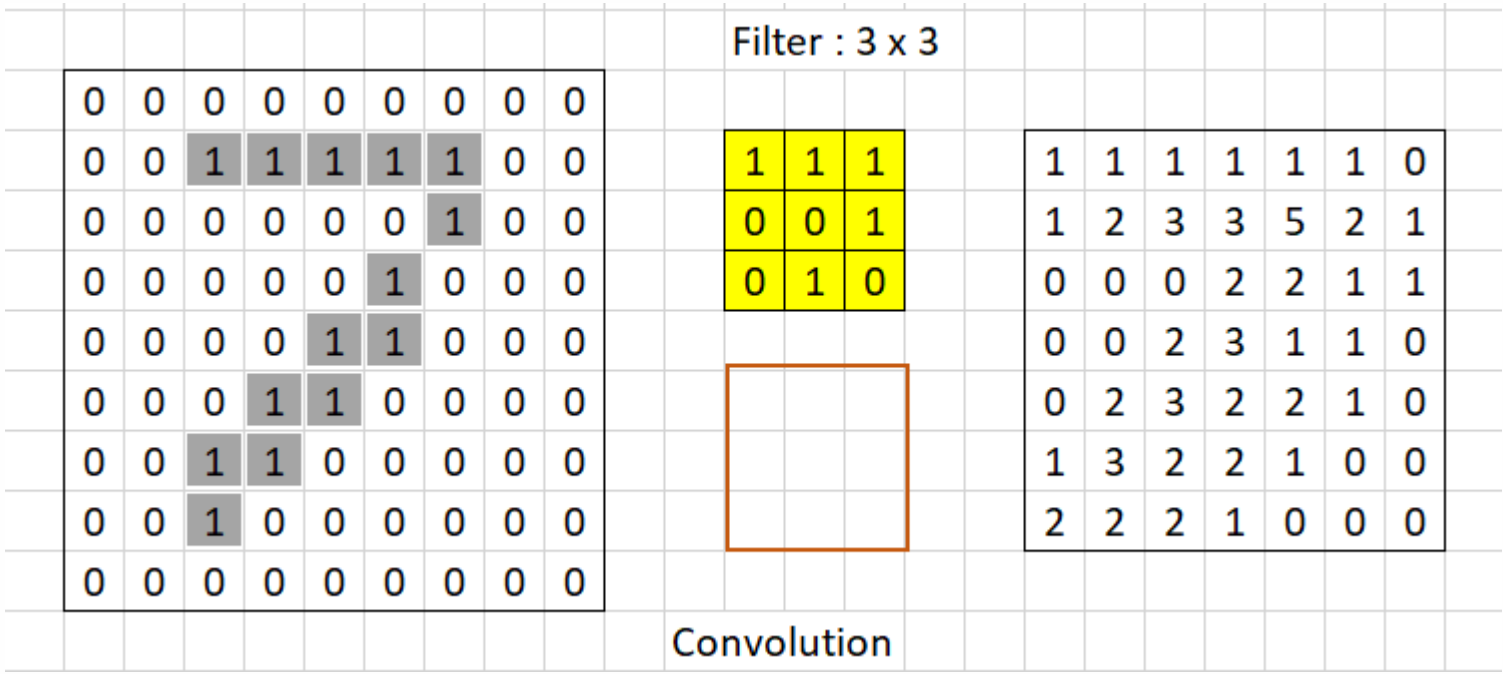
Filter

- We now consider a 3 x 3 filter

0	0	0	0	0	0	0	0	0
0	0	1	1	1	1	1	0	0
0	0	0	0	0	0	1	0	0
0	0	0	0	0	1	0	0	0
0	0	0	0	1	1	0	0	0
0	0	0	1	1	0	0	0	0
0	0	1	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

1	1	1
0	0	1
0	1	0

Convolved Image



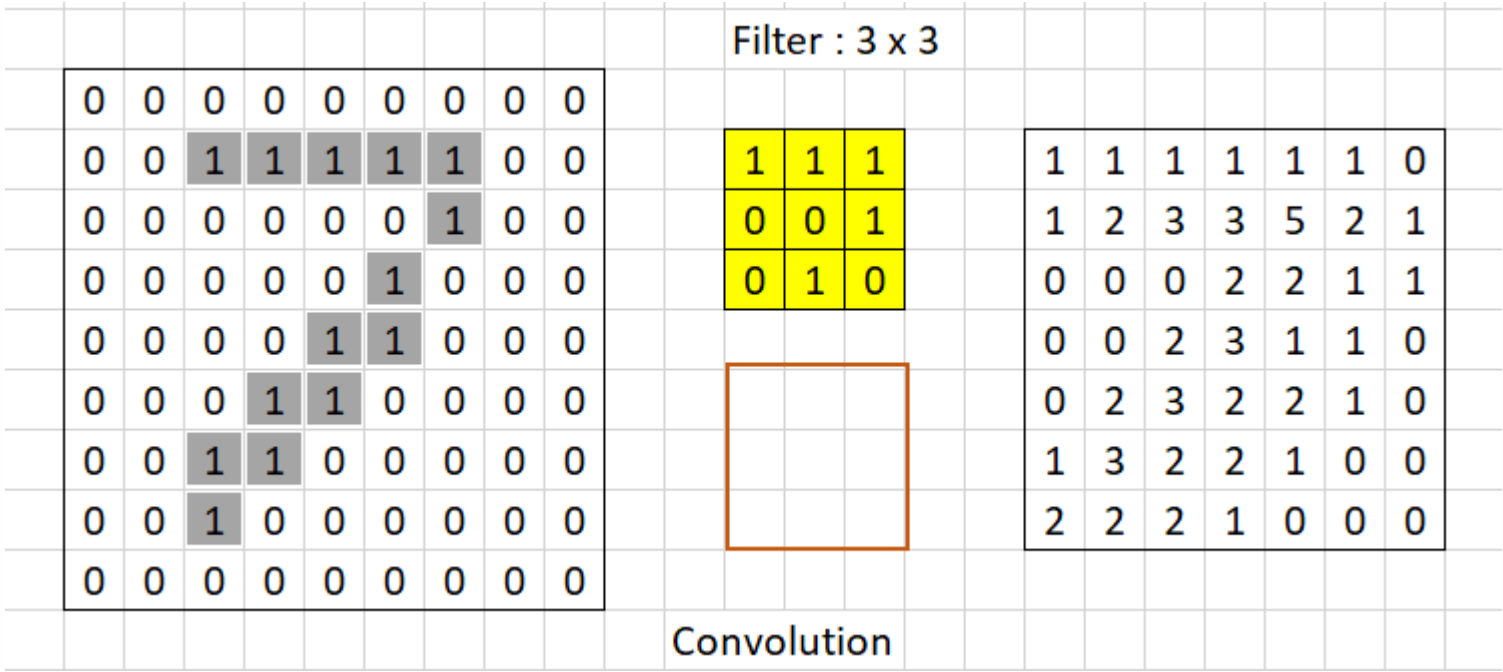
Convolution in Practice

- There are several types of filters. For more information you may go to link: https://lodev.org/cgtutor/filtering.html
- The filter values in the example may not be specific hand-picked values, but can be any set of parameters namely w1,w2,… which need to be tuned for the image

w_1	w_2	w_3
w_4	w_5	w_6
w_7	w_8	w_9

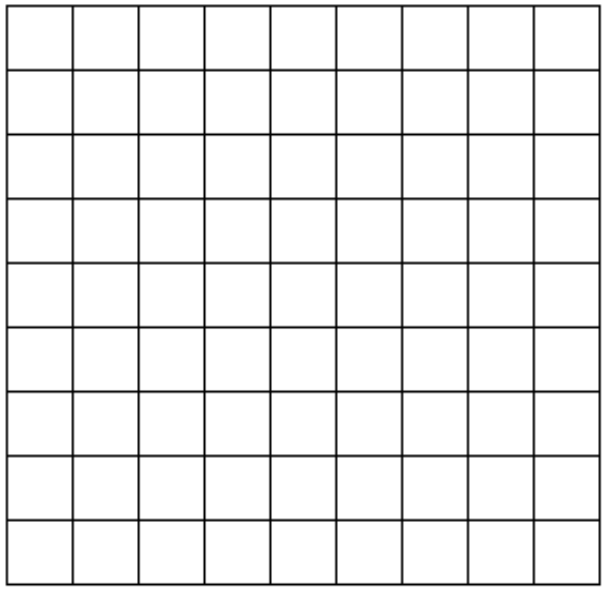
Shrinking of Image

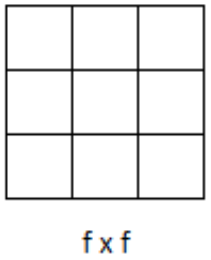
- Each time when you apply the convolution filter, the image shrinks
  e.g. 9 x 9 image getting reduced to 7 x 7 image

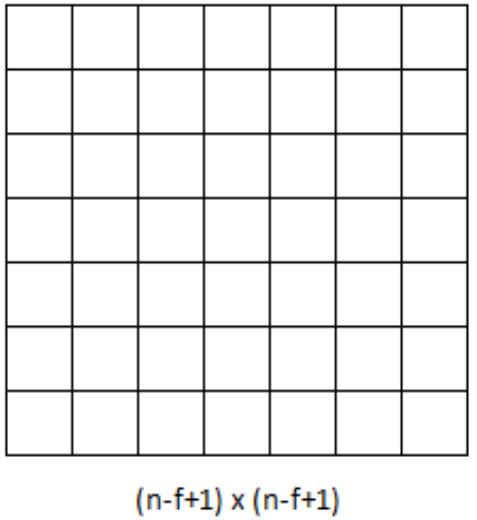


Shrinking of Image

- The image of n x n when convolved by f x f filter gets reduced to (n-f+1) x (n-f+1) image





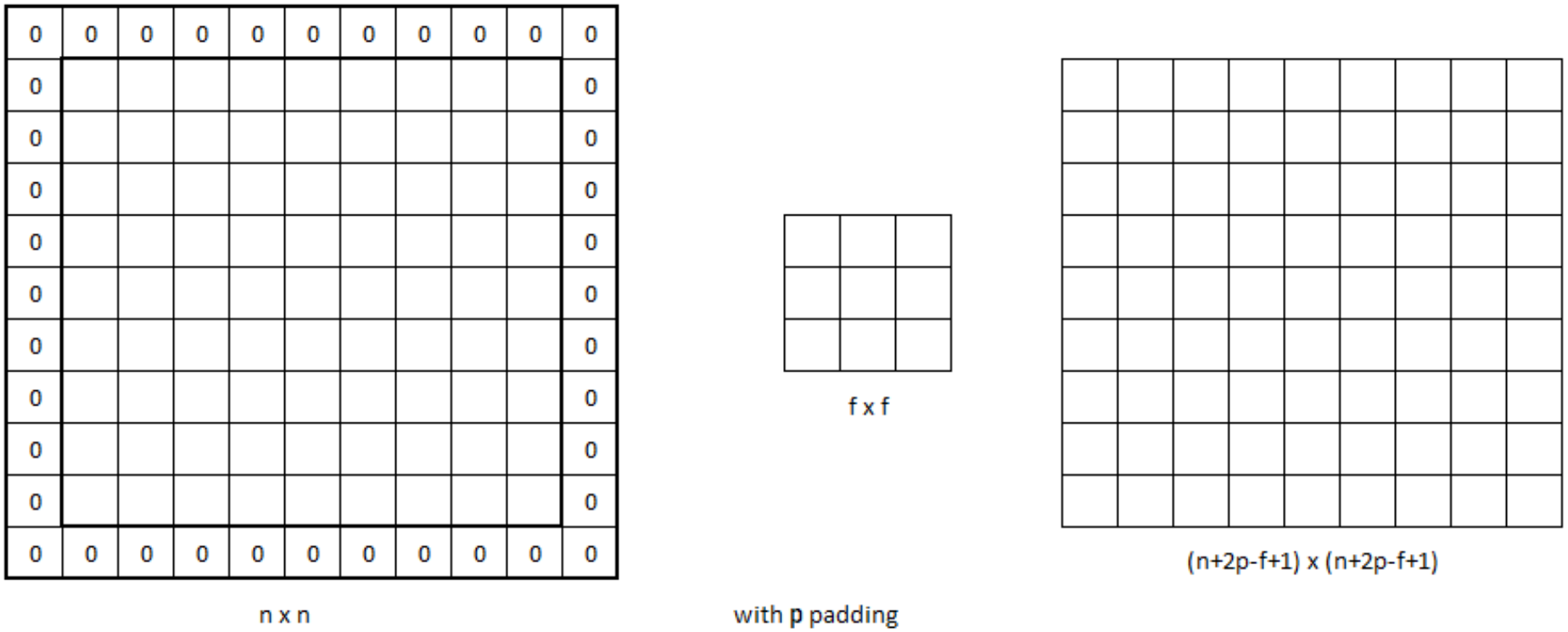


Padding

- Problem with shrinking of the image is that, the cells which not on the edge have less participation in calculation of convolution
- Also for each convolution operation, the image gets shrunk
- If we pad the image before we convolve then both of the above issues get avoided.
- We can have a padding of any number of cells say p

Padding

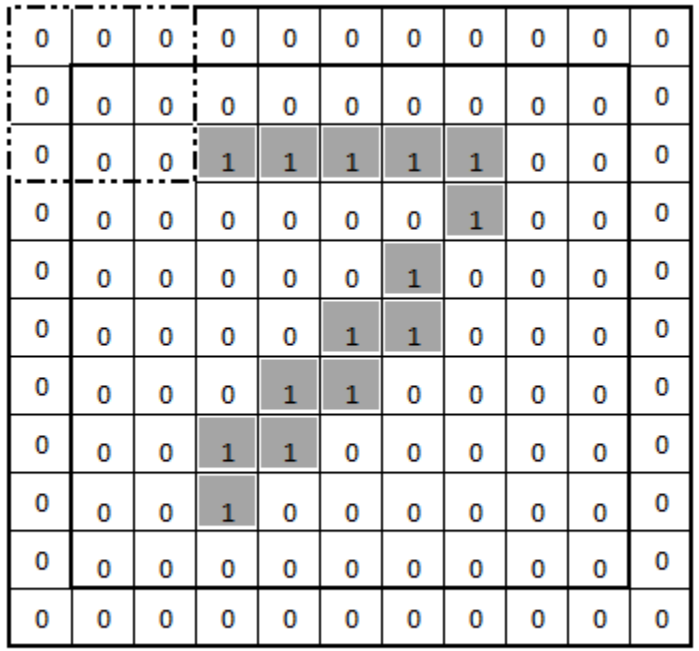
- The image of n x n when convolved by f x f filter, with padding **p** gets reduced to (n+2p-f+1) x (n+2p-f+1) image, which generates the image of same size as original one provided f is odd numbered.



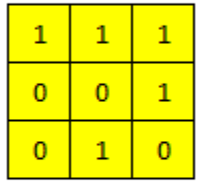
Sane's STATS Academy of Statistics

Strides

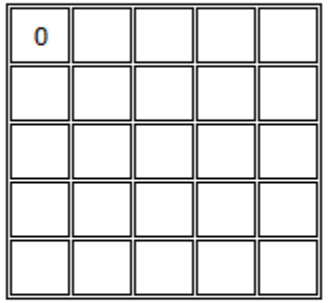
- Instead of going one cell, we can go 2 cells or more cells ahead while we convolve



n x n



f x f



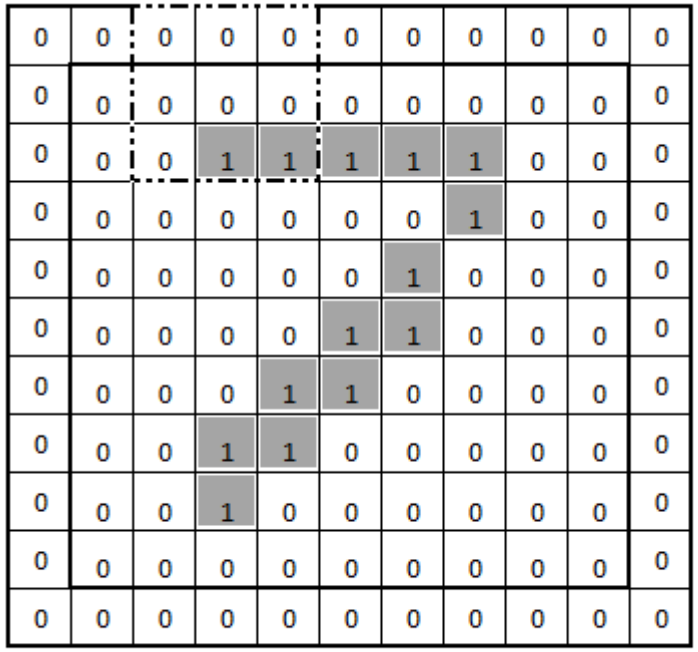
(n+2p-f+1)/s x (n+2p-f+1)/s

with **p** padding, **s** strides

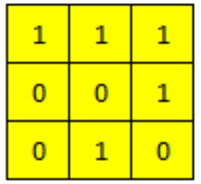
Sane's STATS Academy of Statistics

Strides

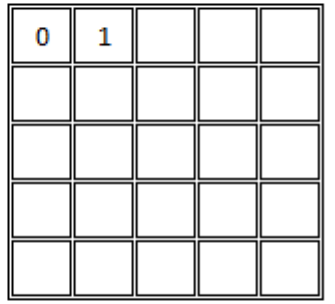
- With Padding p = 1, s = 2, we will have output image as 5 x 5, by flooring the term (n+2p-f+1)/s



n x n



f x f



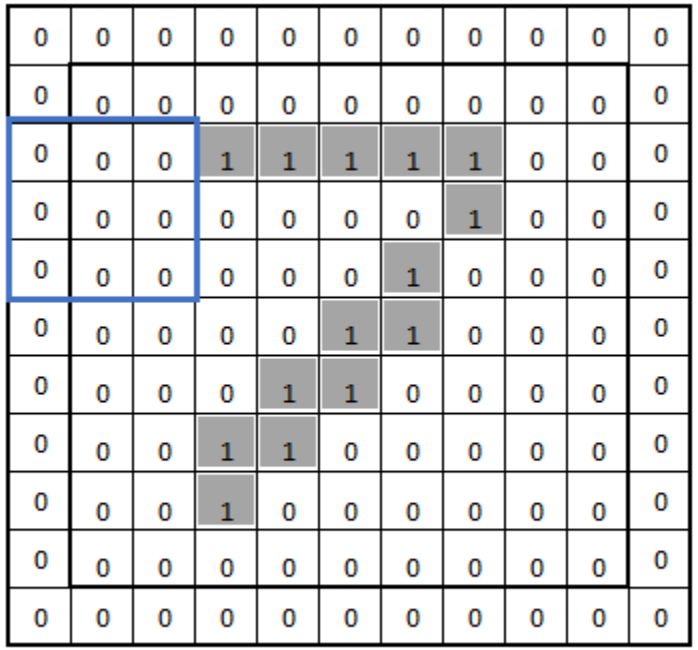
(n+2p-f+1)/s x (n+2p-f+1)/s

with **p** padding, **s** strides

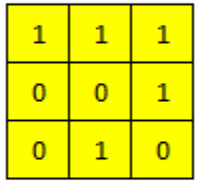
Sane's STATS Academy of Statistics

Strides

- With Padding p = 1, s = 2, we will have output image as 5 x 5, by flooring the term (n+2p-f+1)/s

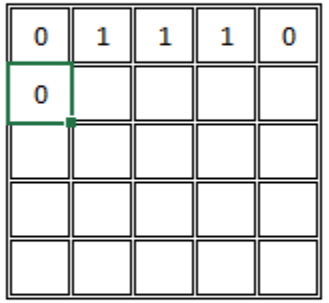


n x n



f x f

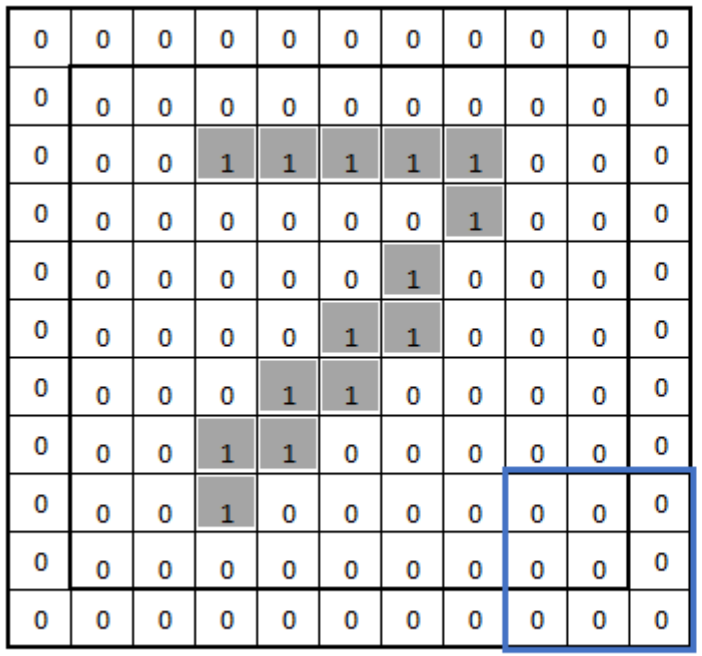
with **p** padding, **s** strides



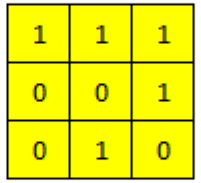
(n+2p-f+1)/s x (n+2p-f+1)/s

Strides

- Finally, we have the following output

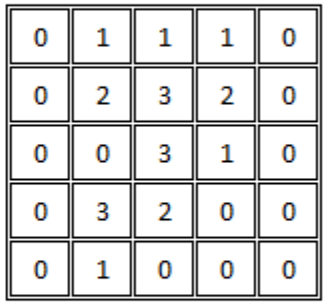


n x n



f x f

with **p** padding, **s** strides



(n+2p-f+1)/s x (n+2p-f+1)/s