

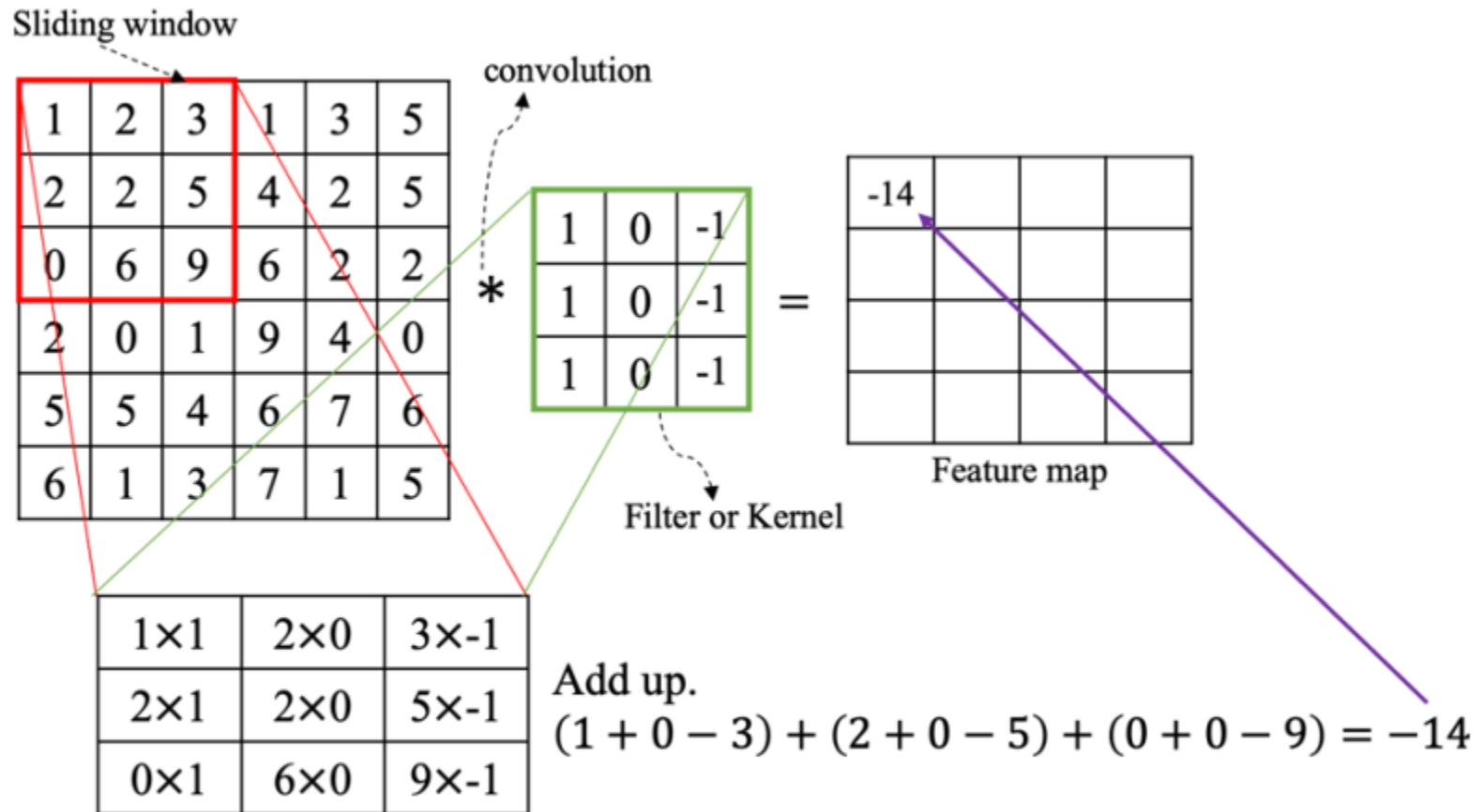


# Digital Image Processing

Sobel Edge Detection, Image  
Sharpening and Gaussian Blur

22-Jun-22

# Convolution Operation



Created by  brilliantcode.net

# Convolution Operation

Sliding window



1	2	3	1	3	5
2	2	5	4	2	5
0	6	9	6	2	2
2	0	1	9	4	0
5	5	4	6	7	6
6	1	3	7	1	5

\*

1	0	-1
1	0	-1
1	0	-1

=

-14	-1		

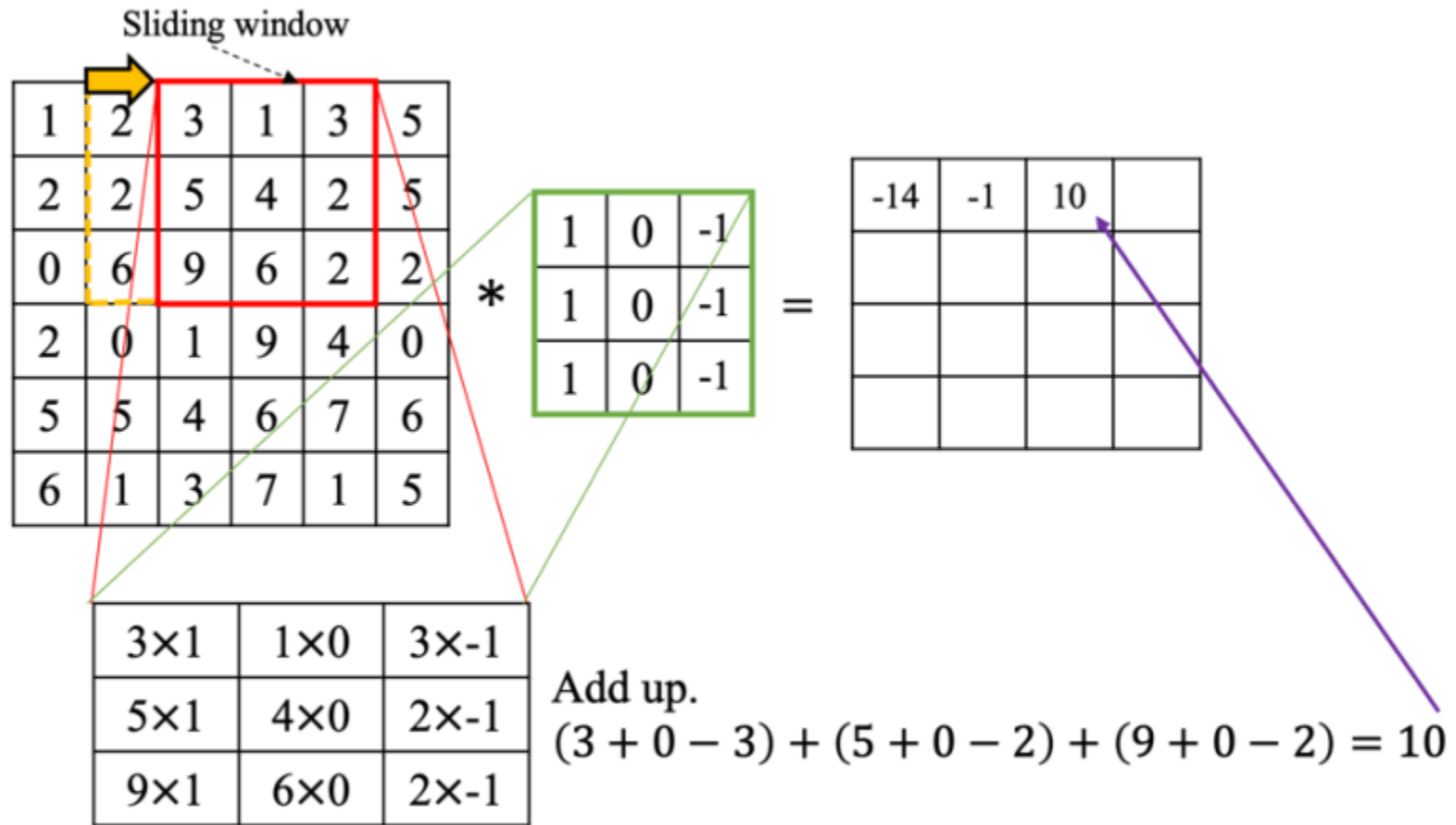
2×1	3×0	1×-1
2×1	5×0	4×-1
6×1	9×0	6×-1

Add up.

$$(2 + 0 - 1) + (2 + 0 - 4) + (6 + 0 - 6) = -1$$

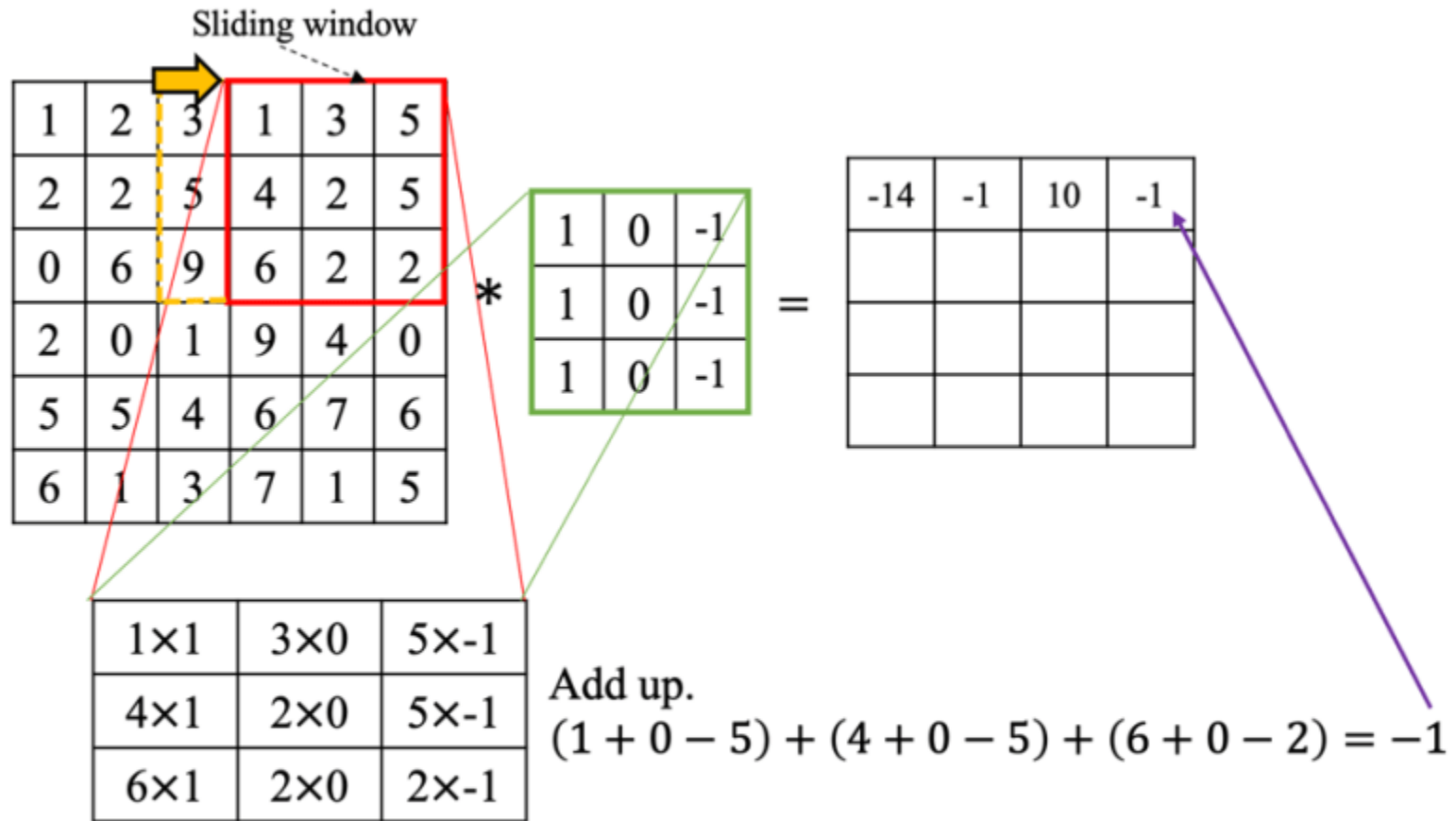
Created by brilliantcode.net

# Convolution Operation



Created by brilliantcode.net

# Convolution Operation



Created by brilliantcode.net

# Convolution Operation

Sliding window

1	2	1	3	5	
2	2	5	4	2	5
0	6	9	6	2	2
2	0	1	9	4	0
5	5	4	6	7	6
6	1	3	7	1	5

\*

1	0	-1
1	0	-1
1	0	-1

=

-14	-1	10	-1
-10			

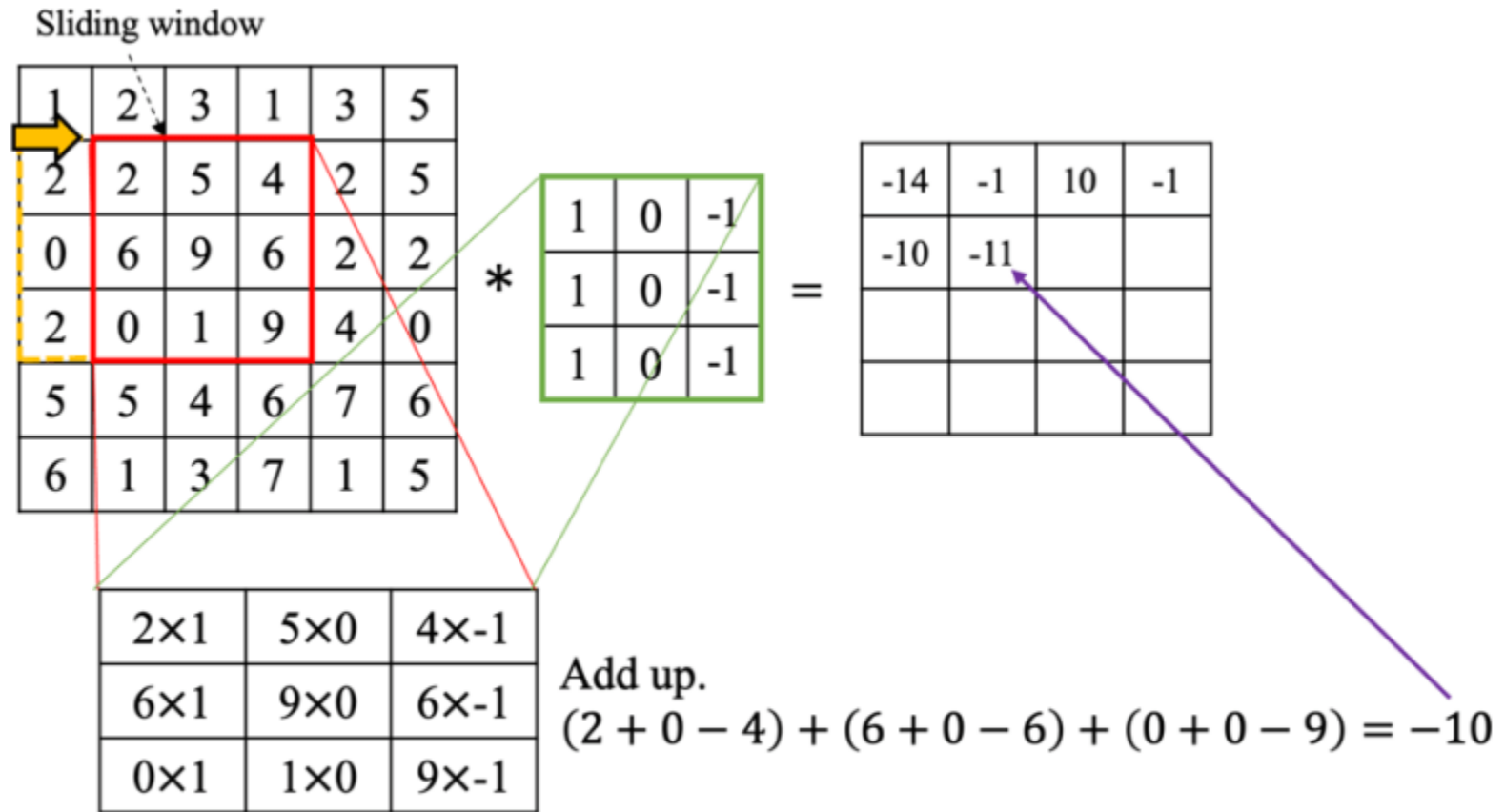
2×1	2×0	5×-1
0×1	6×0	9×-1
2×1	0×0	1×-1

Add up.

$$(2 + 0 - 5) + (0 + 0 - 9) + (2 + 0 - 1) = -10$$

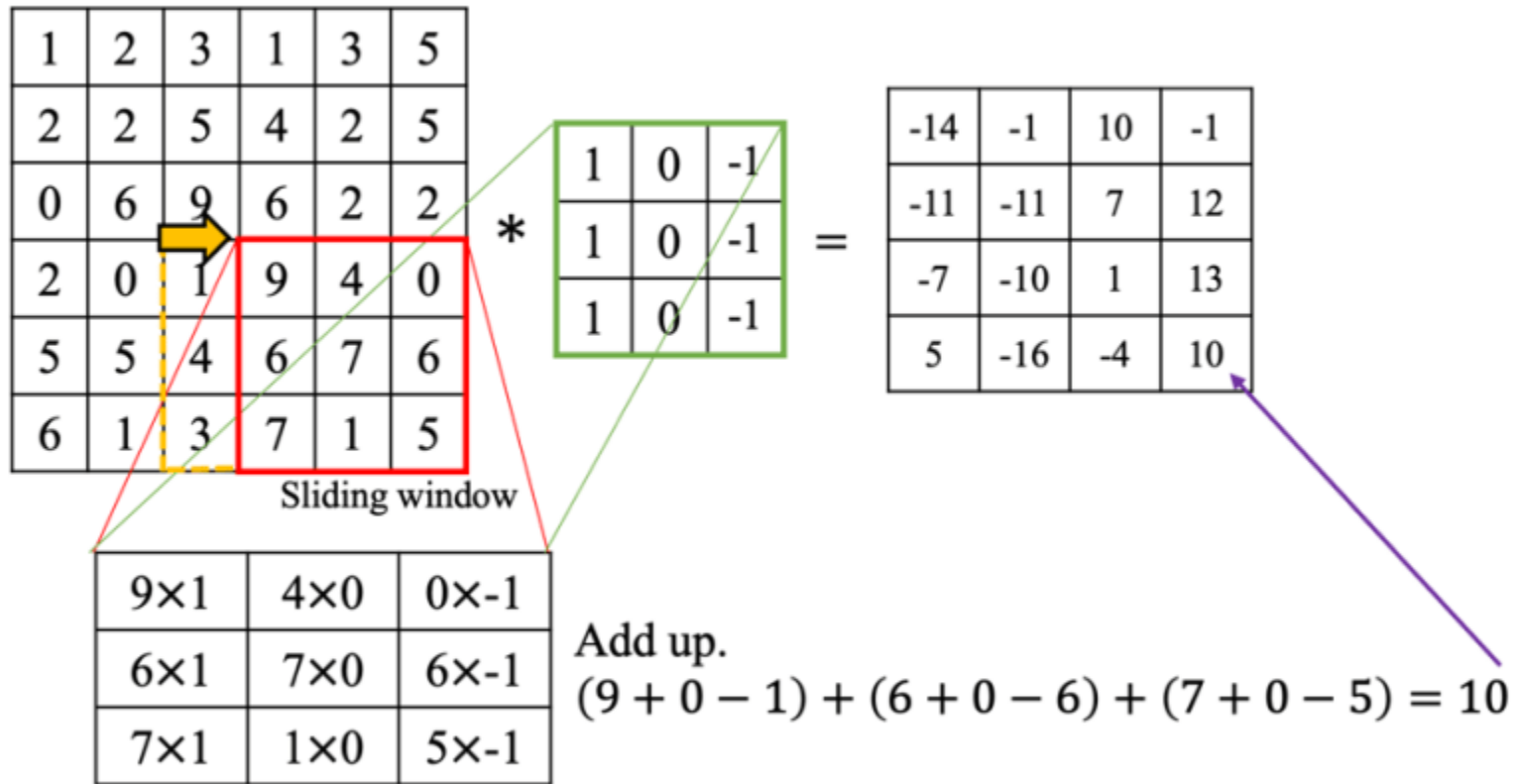
Created by brilliantcode.net

# Convolution Operation



Created by brilliantcode.net

# Convolution Operation



Created by brilliantcode.net



# Convolution Operation

(a) Stride = 1

Input Grid (6x6):

1	2	3	1	3	5
2	2	5	4	2	5
0	6	9	6	2	2
2	0	1	9	4	0
5	5	4	6	7	6
6	1	3	7	1	5

Kernel (3x3):

1	0	-1
1	0	-1
1	0	-1

Output Grid (4x4):

-14	-1	10	-1
-11	-11	7	12
-7	-10	1	13
5	-16	-4	10

(b) Stride = 2

Input Grid (6x6):

1	2	3	1	3	5
2	2	5	4	2	5
0	6	9	6	2	2
2	0	1	9	4	0
5	5	4	6	7	6
6	1	3	7	1	5

Kernel (3x3):

1	0	-1
1	0	-1
1	0	-1

Output Grid (2x2):

-14	10
-7	1

Created by brilliantcode.net

# Zero Padding

0	0	0	0	0	0	0	0
0	1	2	3	1	3	5	0
0	2	2	5	4	2	5	0
0	0	6	9	6	2	2	0
0	2	0	1	9	4	0	0
0	5	5	4	6	7	6	0
0	6	1	3	7	1	5	0
0	0	0	0	0	0	0	0

 \* 

1	0	-1
1	0	-1
1	0	-1

 = 

-4	-5	-1	3	-5	5
-10	-14	-1	10	-1	7
-8	-11	-11	7	12	8
11	-7	-10	1	13	13
-6	5	-16	-4	10	12
-6	4	-7	-1	2	8

Parameters for convolution layer:  
Input feature size (n×n)= (6×6)  
Padding (p)= 1 (Zero-padding)  
Stride (s)= 1  
Kernel (f×f) = (3×3)

Calculate the size of output feature map :

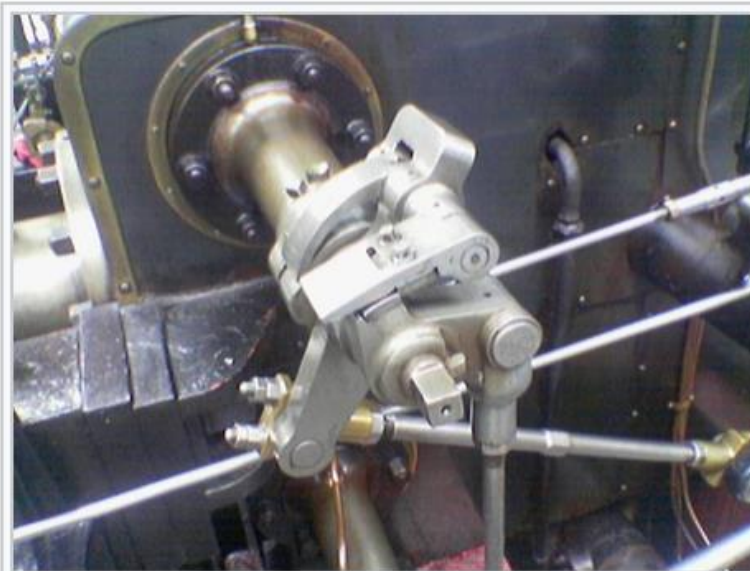
$$\text{floor} \left( \frac{(n+2p-f)}{s} + 1 \right) \\ = \frac{(6 + 2 \times 1 - 3)}{1} + 1 = 6$$

Output feature map = (6×6)

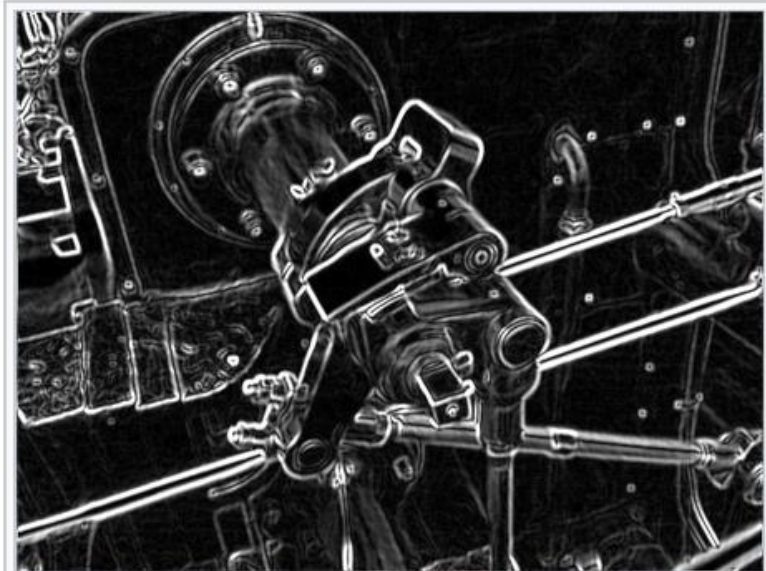
Created by  brilliantcode.net

# Sobel Operator

- ▶ The Sobel operator, sometimes called the Sobel–Feldman operator or Sobel filter, is used in image processing and computer vision, particularly within edge detection algorithms where it creates an image emphasizing edges.



A color picture of a steam engine



The Sobel operator applied to that image



# Sobel Operator

Sobel Horizontal Mask

1	2	1
0	0	0
-1	-2	-1

3X3

2	3	4	3	2
1	2	3	2	1
0	0	0	0	0
-1	-2	-3	-2	-1
-2	-3	-4	-3	-2

5X5

3	4	5	6	5	4	3
2	3	4	5	4	3	2
1	2	3	4	3	2	1
0	0	0	0	0	0	0
-1	-2	-3	-4	-3	-2	-1
-2	-3	-4	-5	-4	-3	-2
-3	-4	-5	-6	-5	-4	-3

7X7

Sobel Vertical Mask

1	0	-1
2	0	-2
1	0	-1

2	1	0	-1	-2
3	2	0	-2	-3
4	3	0	-3	-4
3	2	0	-2	-3
2	1	0	-1	-2

3	2	1	0	-1	-2	-3
4	3	2	0	-2	-3	-4
5	4	3	0	-3	-4	-5
6	5	4	0	-4	-5	-6
5	4	3	0	-3	-4	-5
4	3	2	0	-2	-3	-4
3	2	1	0	-1	-2	-3

# Other Operators

---

- Prewitt operator

$$\begin{bmatrix} +1 & 0 & -1 \\ +1 & 0 & -1 \\ +1 & 0 & -1 \end{bmatrix} \begin{bmatrix} +1 & +1 & +1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix}$$

- Laplacian operator

0	-1	0
-1	4	-1
0	-1	0

-1	-1	-1
-1	8	-1
-1	-1	-1

1	-2	1
-2	4	-2
1	-2	1

# Image Sharpening

---

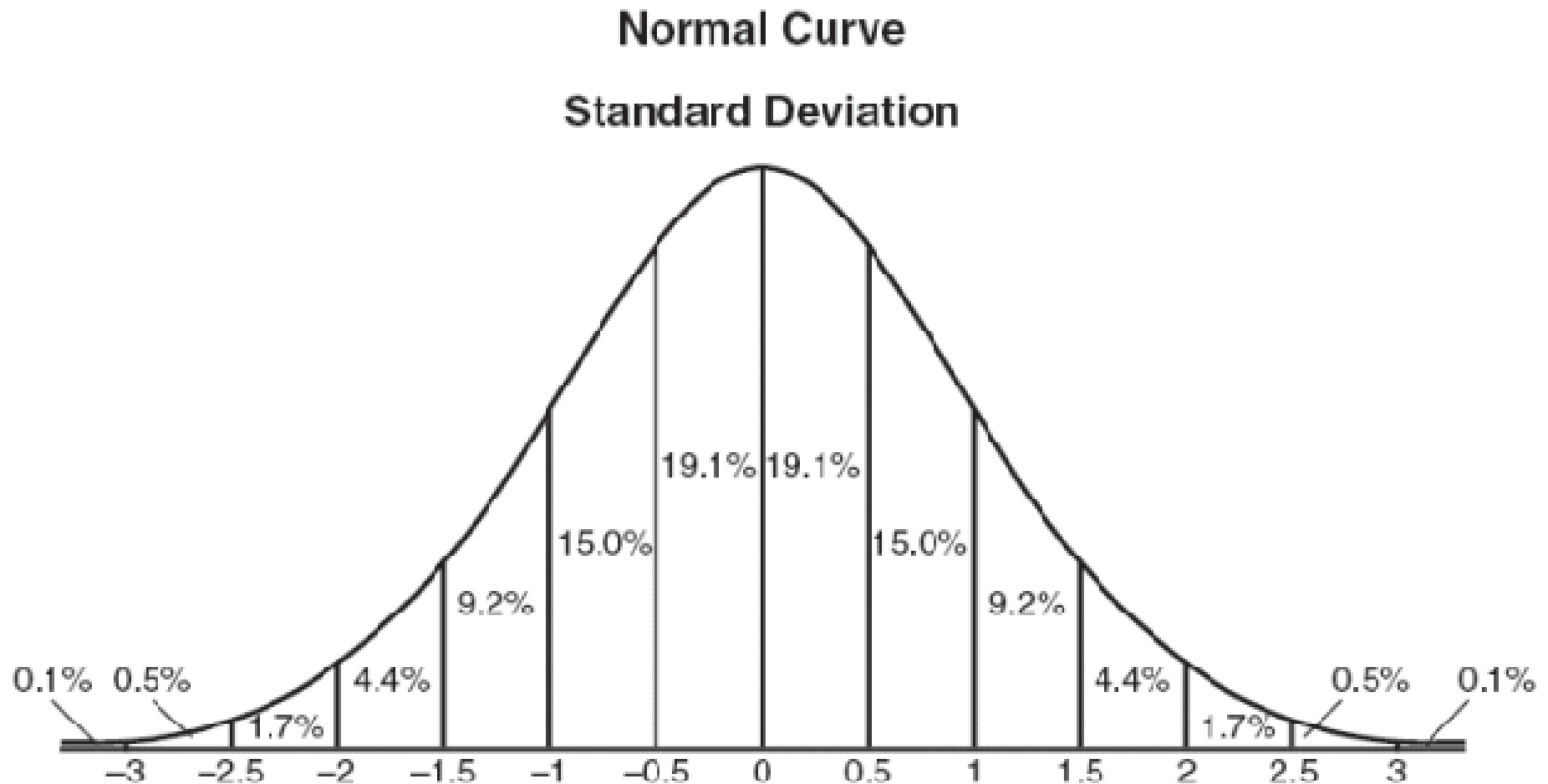
## ► The Image Sharpening Mask



$$\begin{bmatrix} 0 & -a & 0 \\ -a & 4a+1 & -a \\ 0 & -a & 0 \end{bmatrix}$$

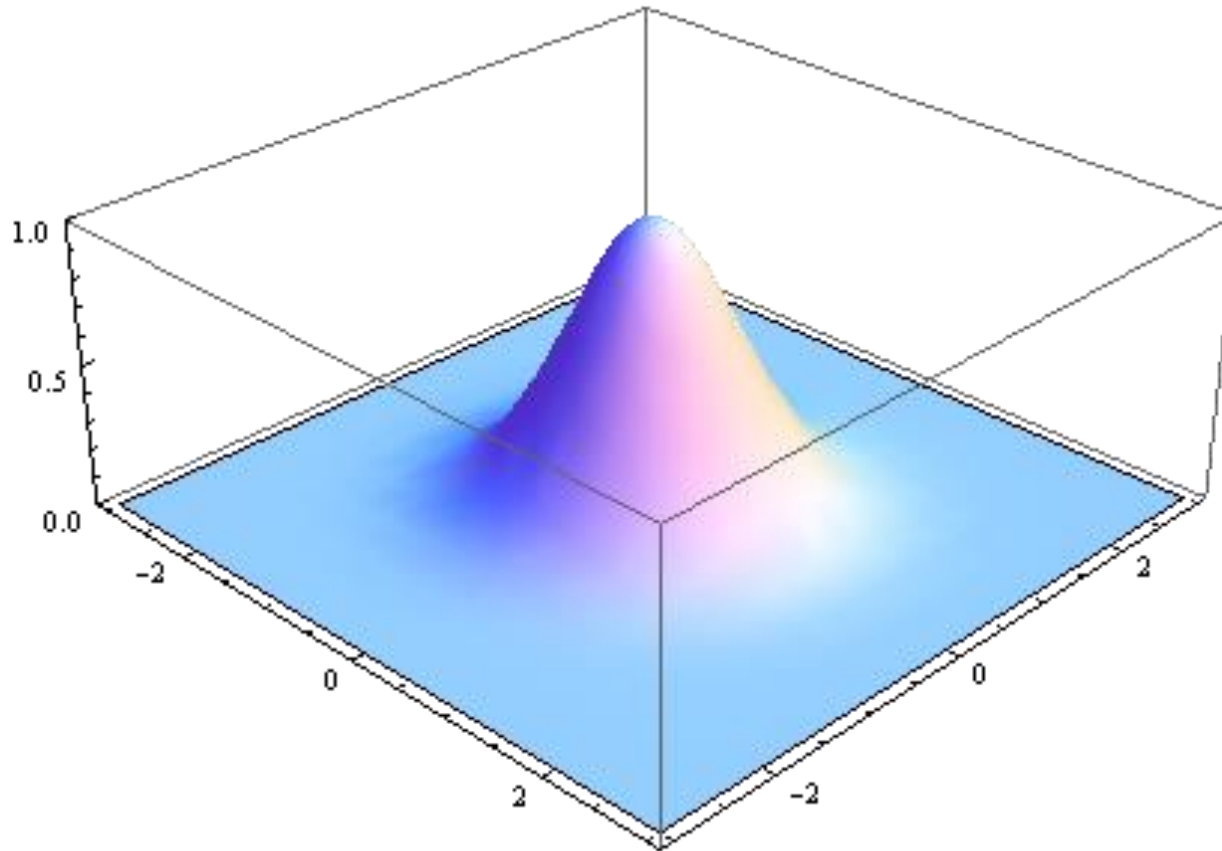
# Gaussian Function

---



# Gaussian function

---



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



# Gaussian Mask

---

- ▶ Assume that the center is  $(0,0)$ ,  $\sigma=1.5$

<b><math>(-1,1)</math></b>	<b><math>(0,1)</math></b>	<b><math>(1,1)</math></b>	<b>0.0453542</b>	<b>0.0566406</b>	<b>0.0453542</b>
<b><math>(-1,0)</math></b>	<b><math>(0,0)</math></b>	<b><math>(1,0)</math></b>	<b>0.0566406</b>	<b>0.0707355</b>	<b>0.0566406</b>
<b><math>(-1,-1)</math></b>	<b><math>(0,-1)</math></b>	<b><math>(1,-1)</math></b>	<b>0.0453542</b>	<b>0.0566406</b>	<b>0.0453542</b>

# References

---

- ▶ [https://en.wikipedia.org/wiki/Sobel\\_operator](https://en.wikipedia.org/wiki/Sobel_operator)
- ▶ <https://blog.csdn.net/farmwang/article/details/74452750>
- ▶ <https://www.brilliantcode.net/1584/convolutional-neural-networks-1-convolution-layer-stride-padding-kernel/>