Computer Vision

Ch.5 Filtering

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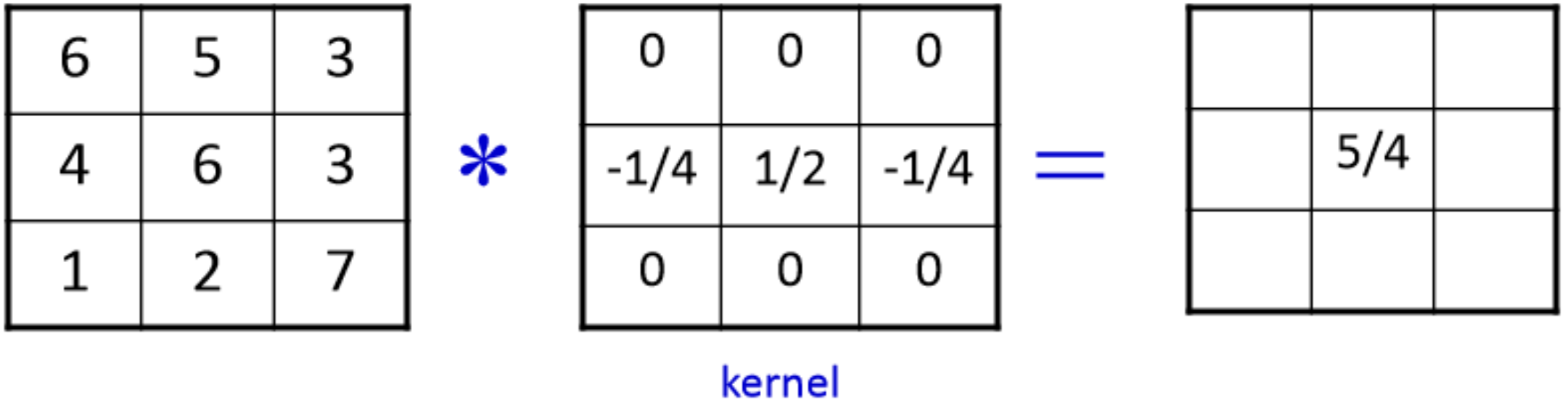
NCUE CSIE

What is filtering?

- ✓ Construct a new image whose pixels are a weighted sum of the original pixel values.
  - Using the same set of weights at each point
  - Mainly based on neighborhood of the target pixels

Linear filtering

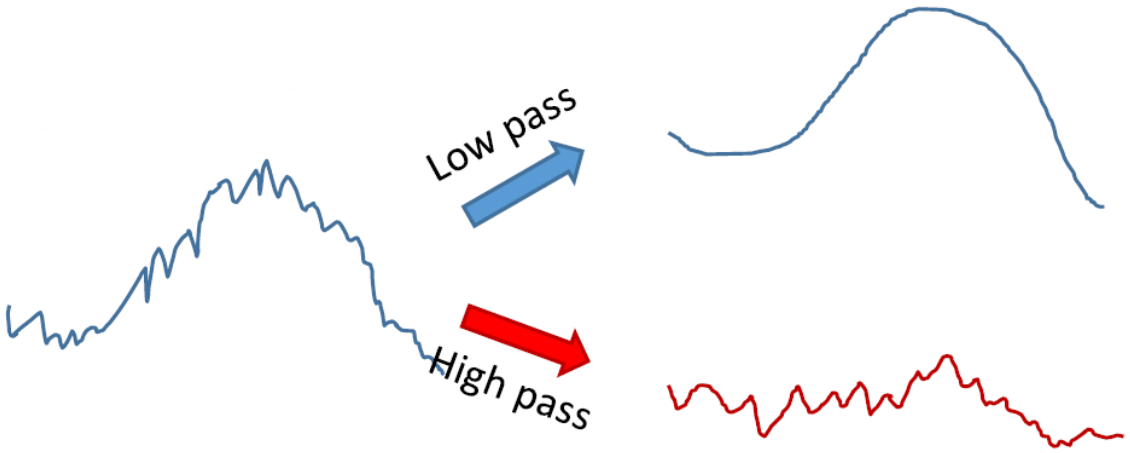
- The simplest and most useful case:
  - Replace each pixel with a linear combination of its neighbors.

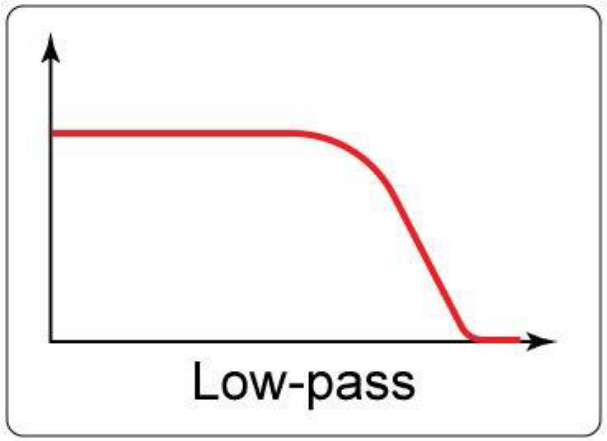


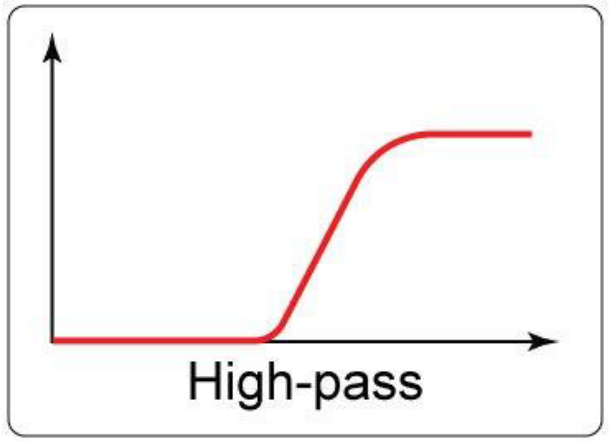
$$F(aX + bY) = a * F(X) + b * F(Y)$$

Filtering introduction

- The term "filter" is derived from the frequency domain.
  - ➢ Refers to accepting or rejecting certain frequency components.
    - High-pass filter only lets high-frequency components pass
    - Low-pass filter only lets low frequency components pass







Filtering processing

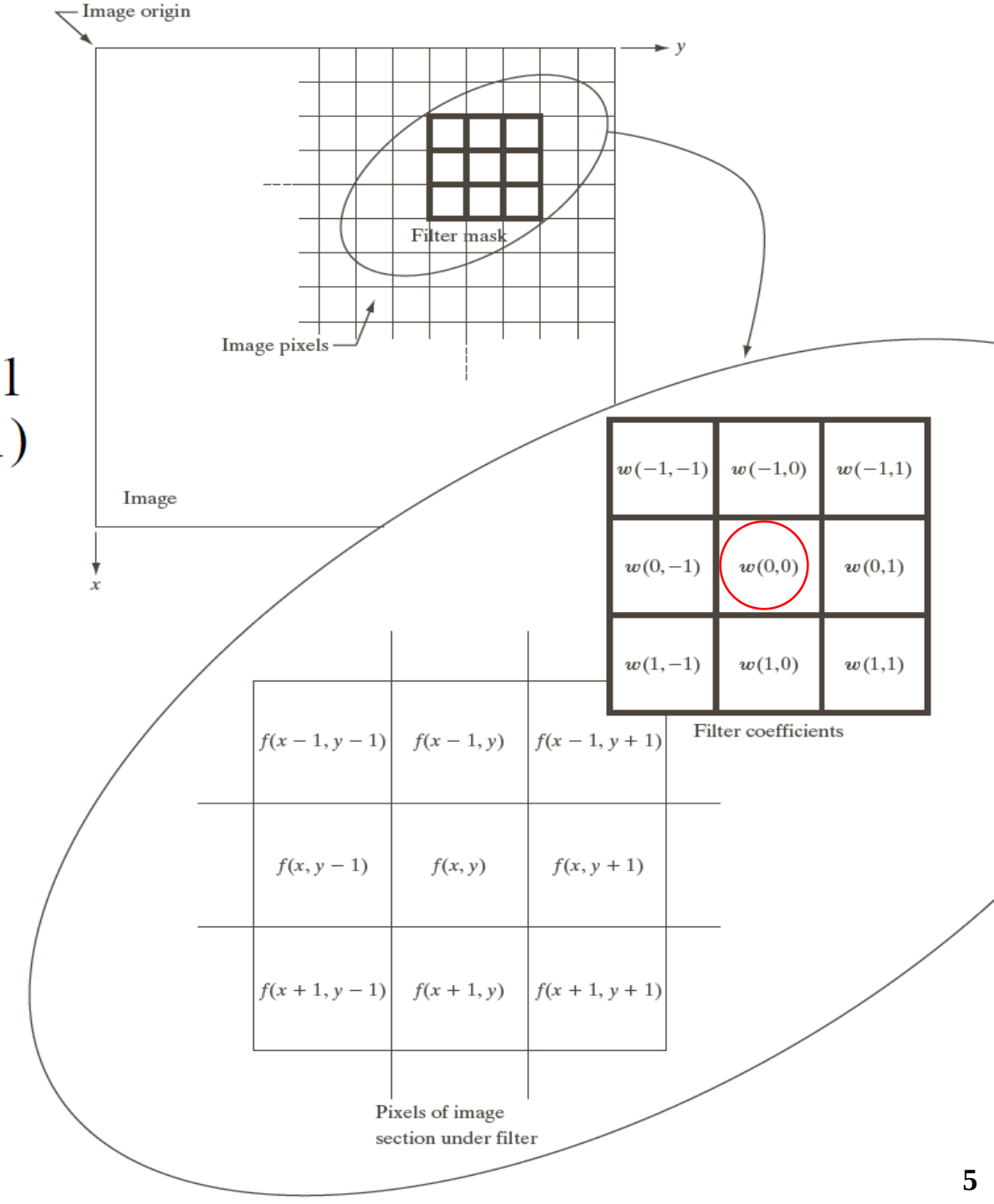
- The sum of image pixel products :

$$g(x, y) = w(-1,-1)\, f(x-1, y-1) + w(-1,0)\, f(x-1, y) + \ldots + w(0,0)\, f(x, y) + w(1, 1)\, f(x+1, y+1)$$

  - The central coefficient w(0, 0) of the filter is aligned with the pixel (x, y).

Note:

- The filter calculation process requires a "new image" to save the result.
- The filtered pixels are rarely replaced with the values in the corresponding positions in the original image, because while the filtering is still in progress, this will change the content of the image.



Example (1/2)

Original

0	0	0
0	1	0
0	0	0

Filtered (no change)

Original

0	0	0
0	0	1
0	0	0

Shifted right By 1 pixel

Example (2/2)

Original

$$\frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$$

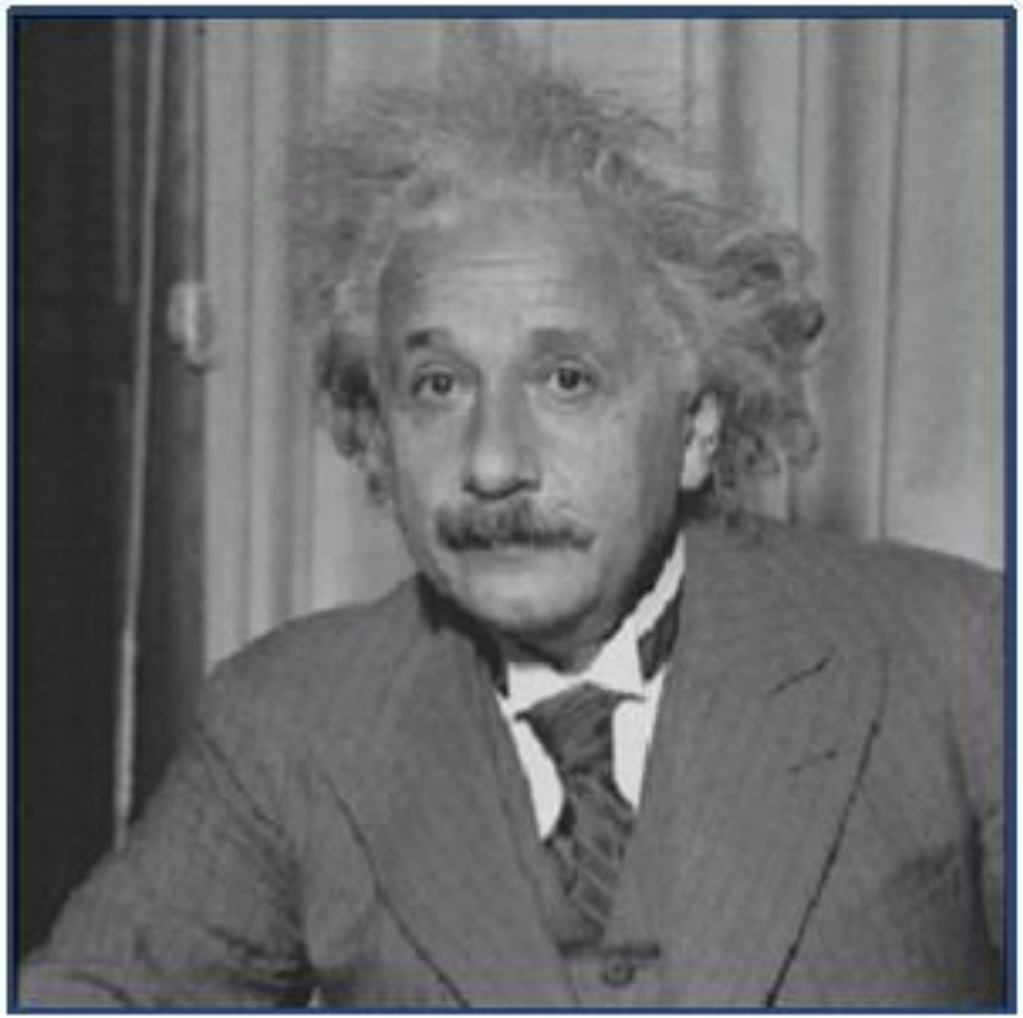
Blur (with a box filter)

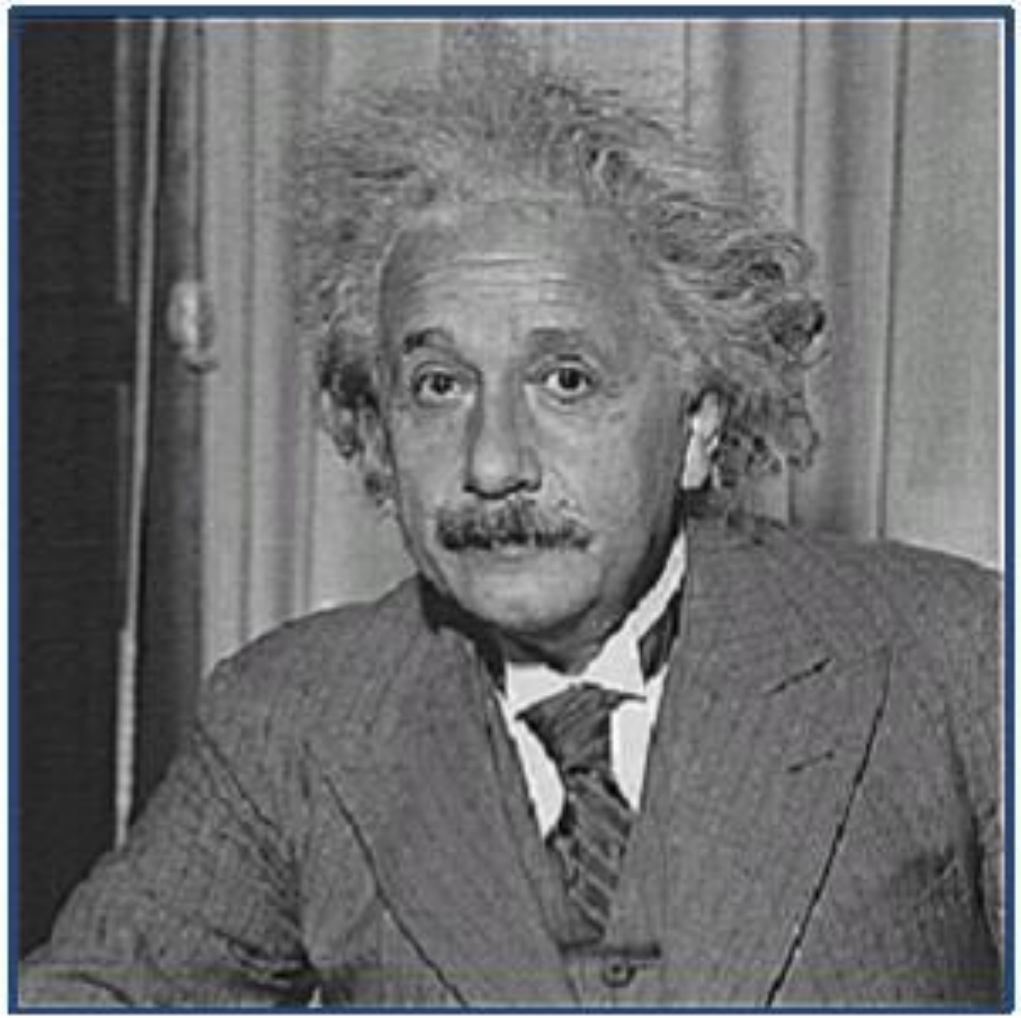
Original

$$\begin{bmatrix}0 & 0 & 0\\ 0 & 2 & 0\\ 0 & 0 & 0\end{bmatrix} - \frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix}$$

Sharpening filter

Sharpening example



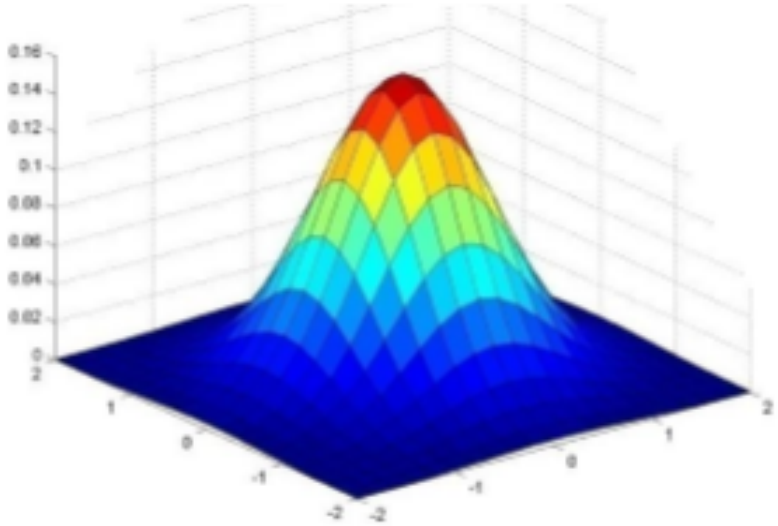


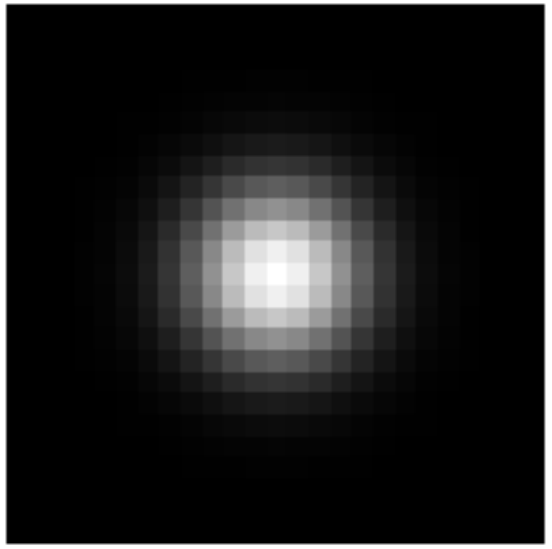
- ✓ Accentuates differences with local average.

Gaussian Kernel

- Weight contributions of neighboring pixels by nearness.

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

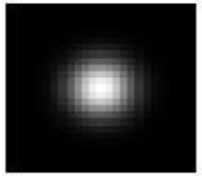


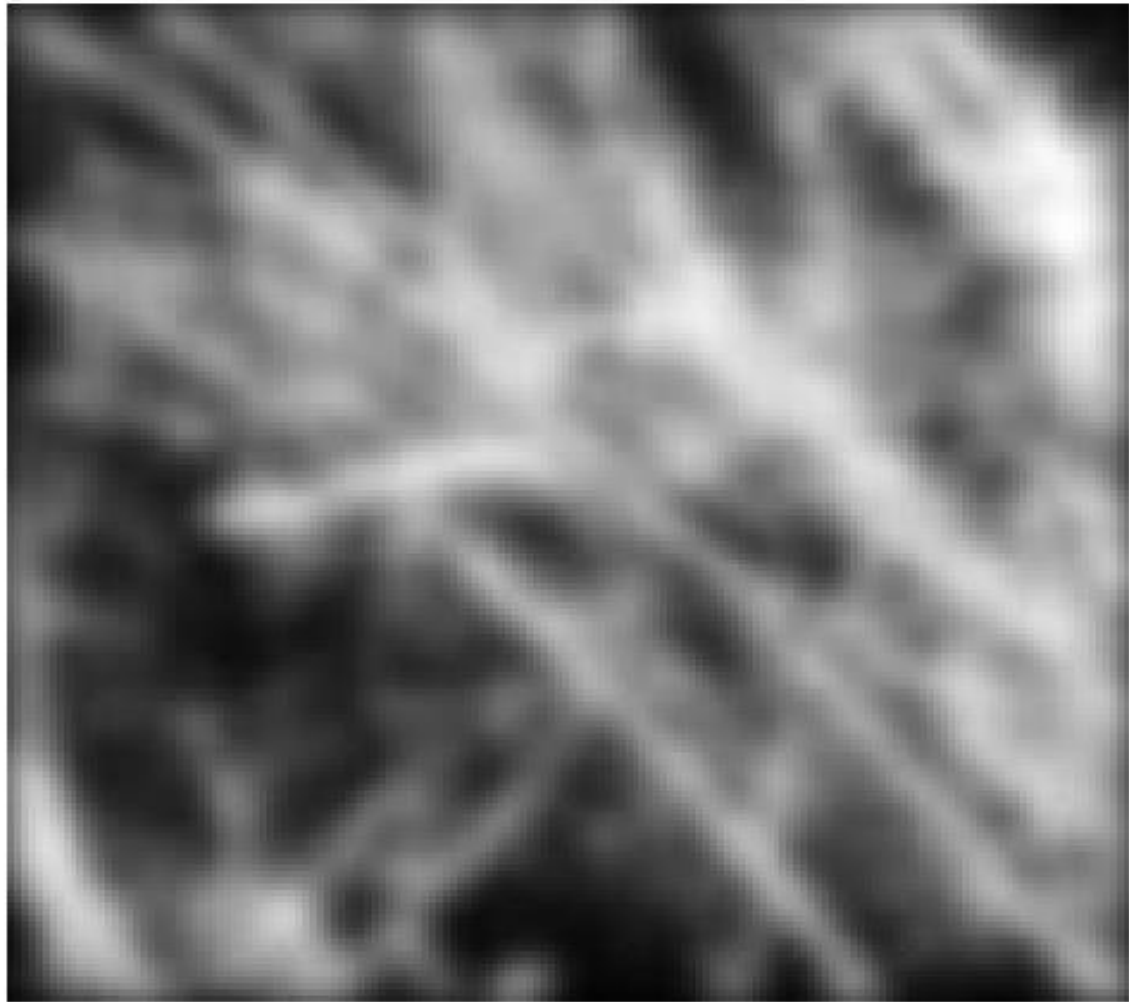


0.003	0.013	0.022	0.013	0.003
0.013	0.059	0.097	0.059	0.013
0.022	0.097	0.159	0.097	0.022
0.013	0.059	0.097	0.059	0.013
0.003	0.013	0.022	0.013	0.003

- For efficiency, usually use integers as weights.

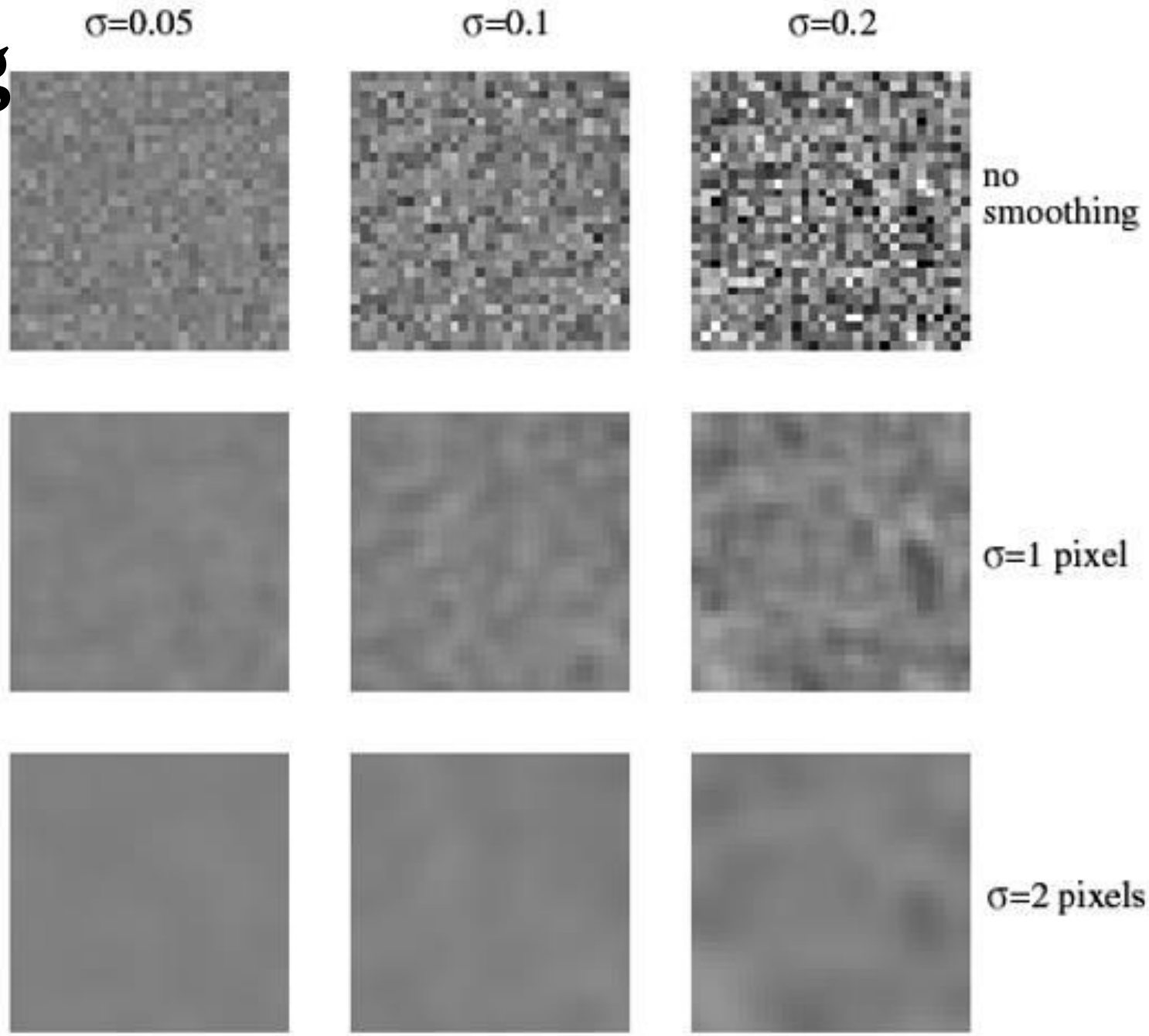
Smoothing with a Gaussian





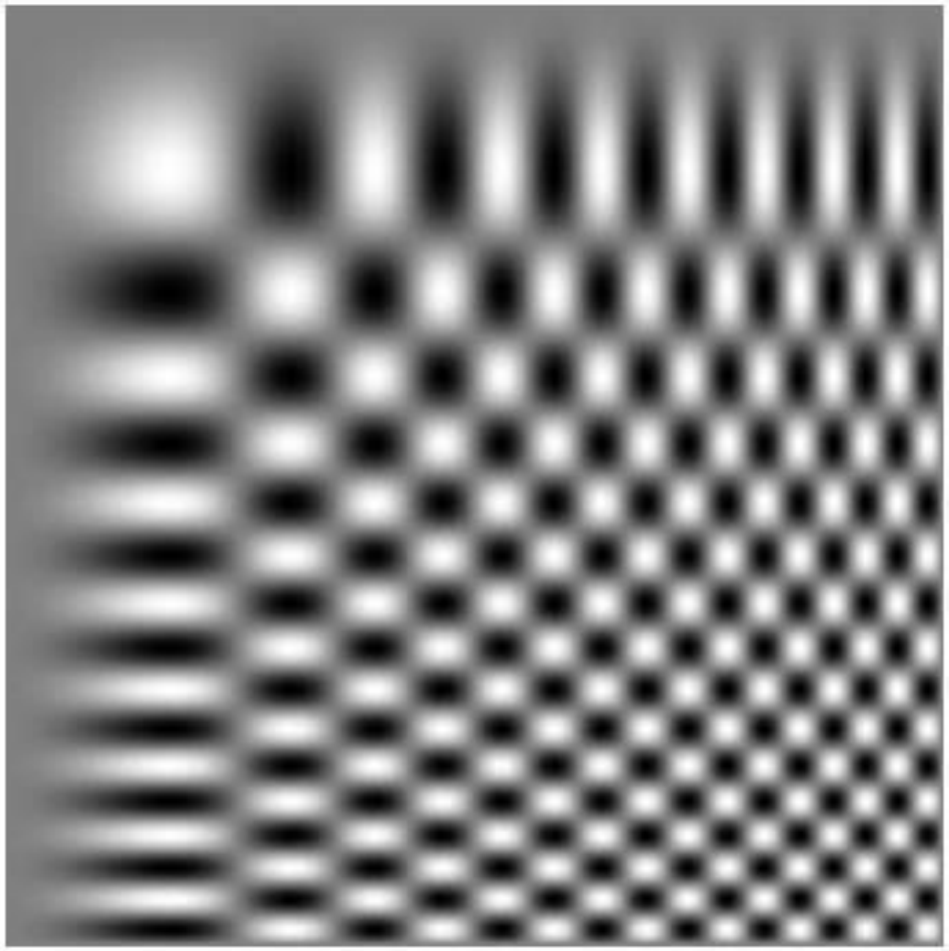
Noise and smoothing

- Smoothing reduces pixel noise:
  - Each row shows smoothing with Gaussians of different width.
  - Each column shows different amounts of Gaussian noise.

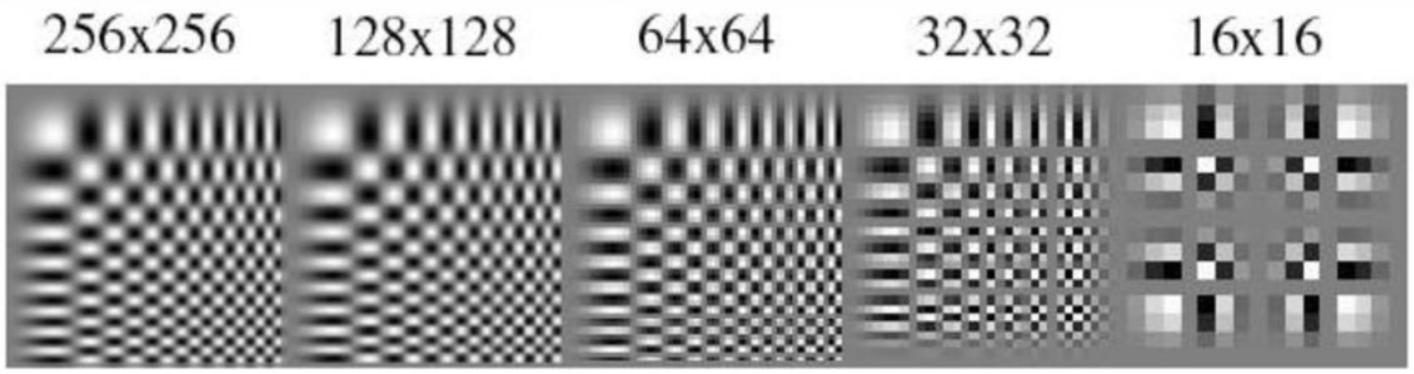


Noise and smoothing

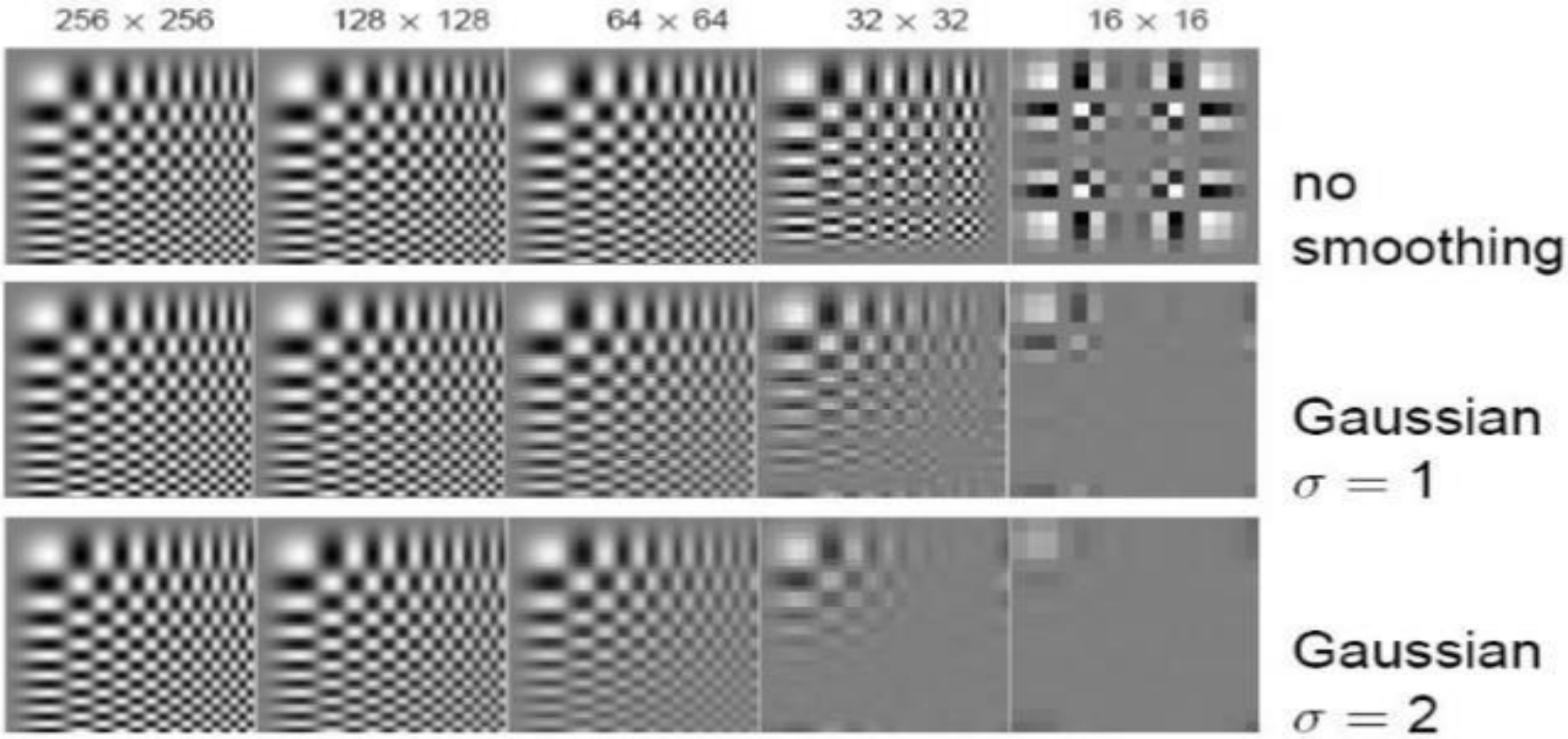
Aliasing



- Simple sampling
  - Take every second pixel.
  - But High frequencies lead to trouble with sampling.



Smoothing as low-pass filtering



Forsyth & Ponce Figures 7.12–7.14 (top rows)

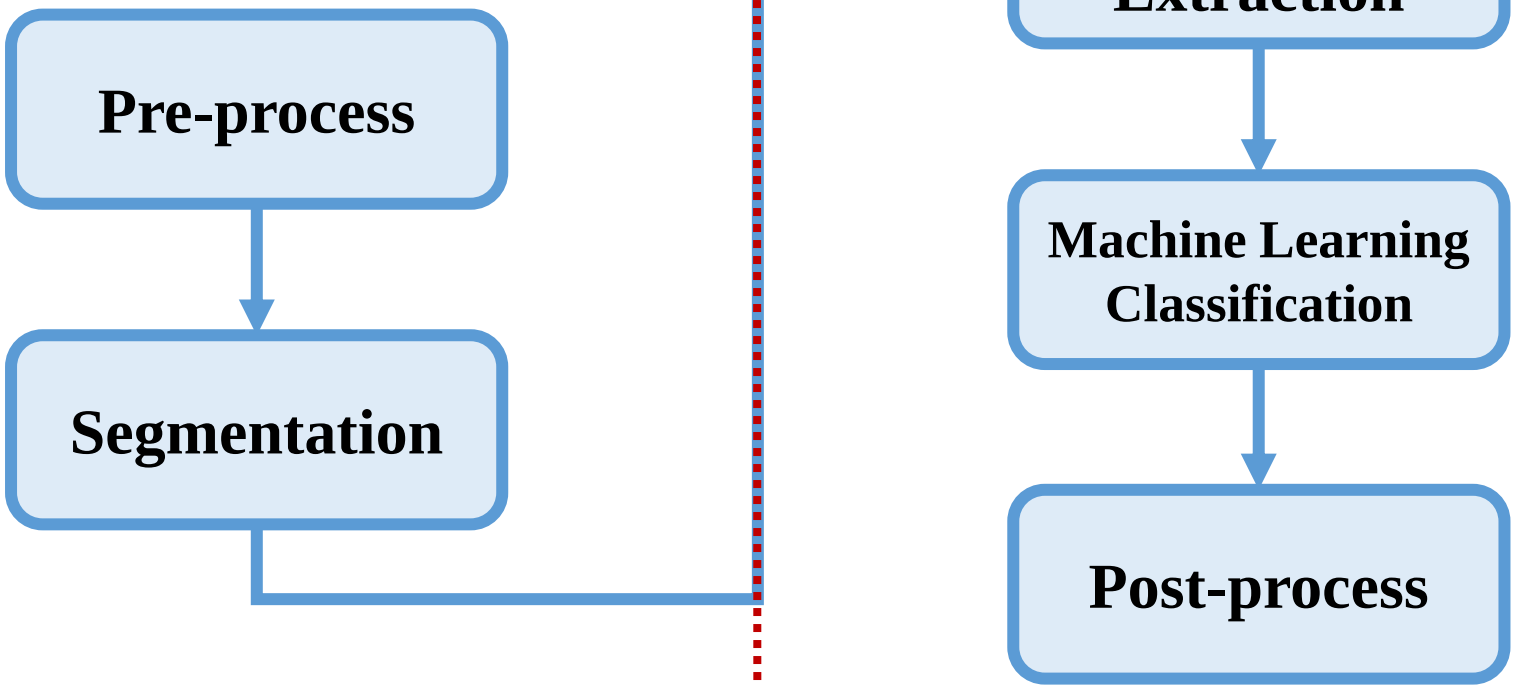
The real application (1/5)

As we mention in the previous…

- Factory production line
- Road analysis
- … etc.

The real application (2/5)

✓ **Combine filtering with chapter 4.**



- **After we finish the previous process.**

The flowchart of common computer vision process.

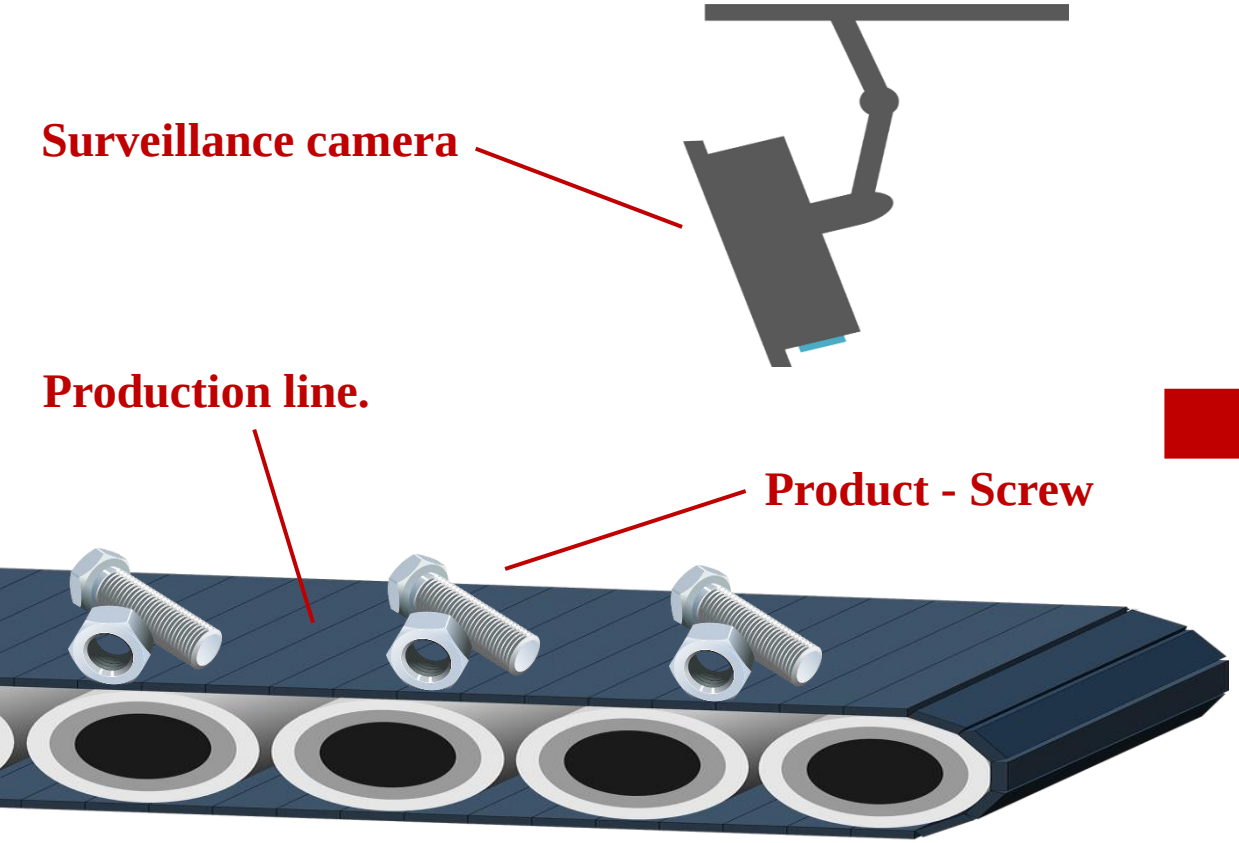
The real application (3/5)

➢ Automated optical inspection (AOI)

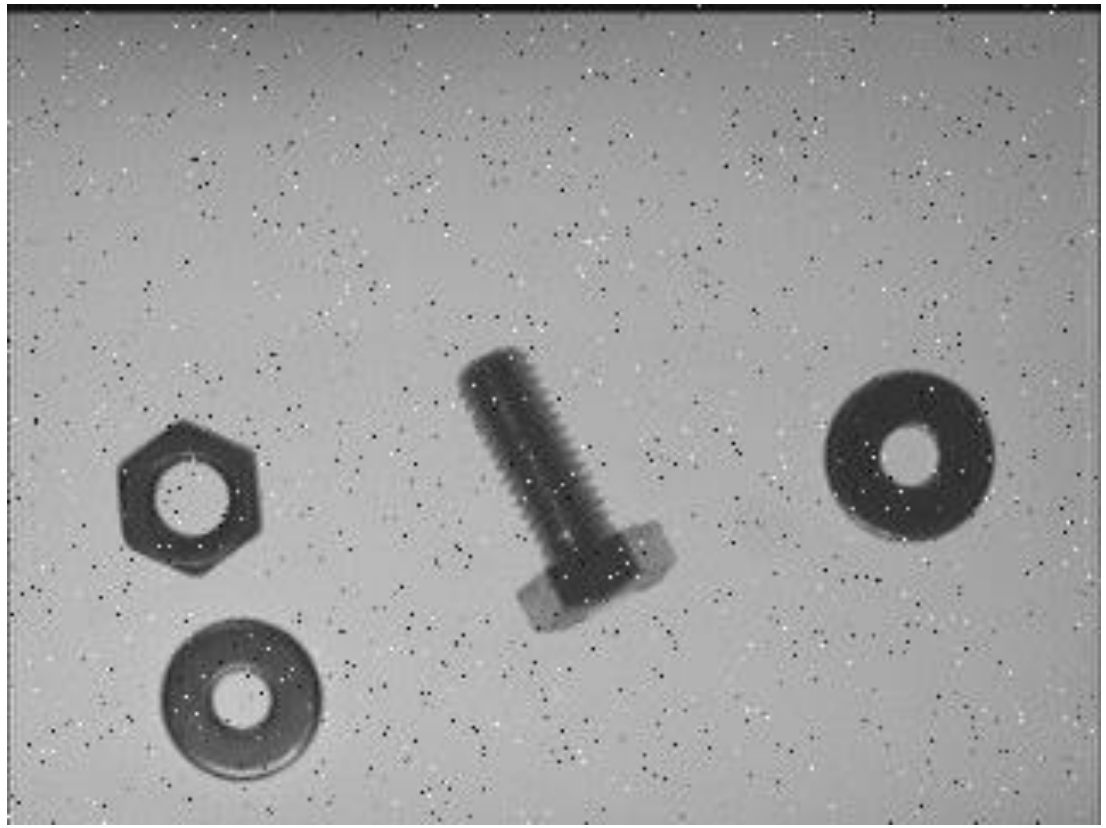
- ✓ Nowadays, Complex computer vision systems and hardware have been used in the industry.
- ✓ To identify the problem in the manufacturing process, reduce errors and improve the quality of the product.

The real application (4/5)

➢ Automated optical inspection (AOI)



Common production line



Capture result

The real application (5/5)

➢ Automated optical inspection (AOI)

國產車工廠大解密

https://youtu.be/GAGuCXJHELM?t=782

Image processing (1/7)

- **Noise**

Common noise

- Salt-pepper noise
- Gaussian noise
- Spike noise
- Shot noise
- … etc.

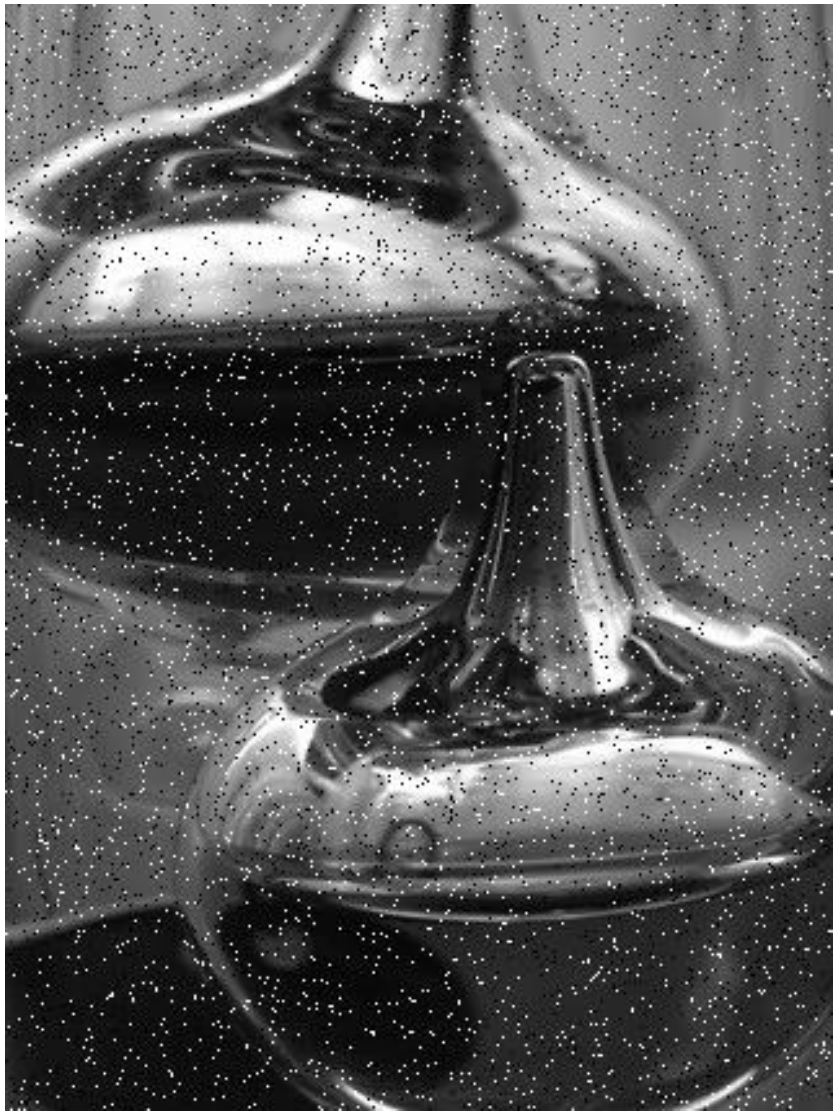


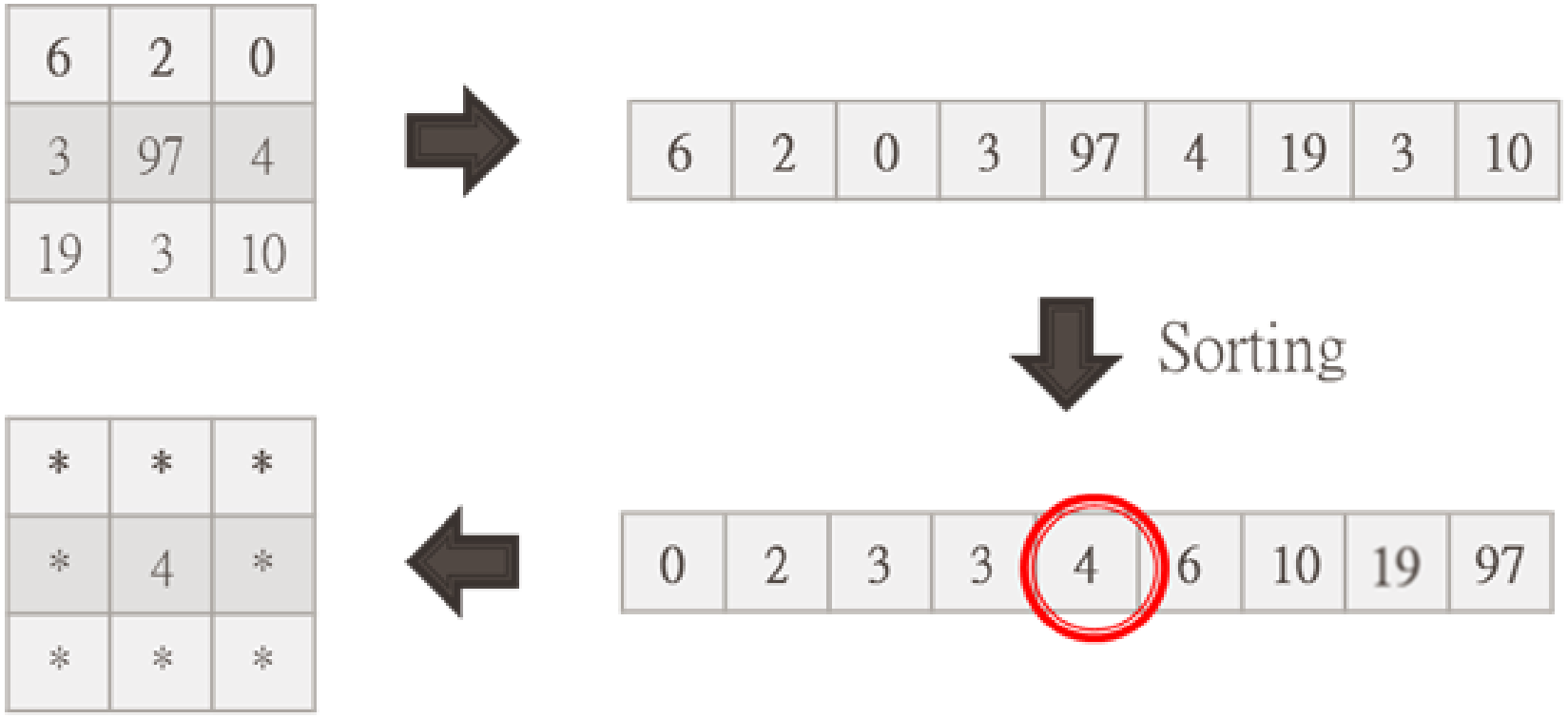
Image with salt and pepper noise

Source: https://en.wikipedia.org/wiki/File:Noise_salt_and_pepper.png

Image processing (2/7)

➢ Median filter

✓ The Median Filter is a non-linear digital filtering technique, often used to remove noise from an image or signal.



Source: https://pic.pimg.tw/honglung/1484949784-577764374.png

Image processing (3/7)

➢ Median filter

✓ Use of a median filter to improve an image severely corrupted by defective pixels.

Source: https://en.wikipedia.org/wiki/File:Medianfilterp.png

Image processing (4/7)

➢ Code – median filter

Syntax:

```
medianBlur(src, dst, ksize);
```

src – Input array input (1-, 3-, or 4-channel image, 8-bit or 32-bit floating point).
dst – Destination array of the same size and type as src.
ksize – Kernel size, Aperture linear size; it must be odd and greater than 1, for example: 3, 5, 7 ....

Image processing (5/7)

➢ Demo code – Median filter

```
Mat rm_Noise;  // Remove the Noise using Median Blur filter.

medianBlur(Noise_Obj,rm_Noise,3);

namedWindow("Remove Noise");
imshow("Remove Noise",rm_Noise);
```

Image processing (6/7)

➢ Lighting Removal

- ✓ In Computer Vision, lighting is a critical problem which can cause noise of result.

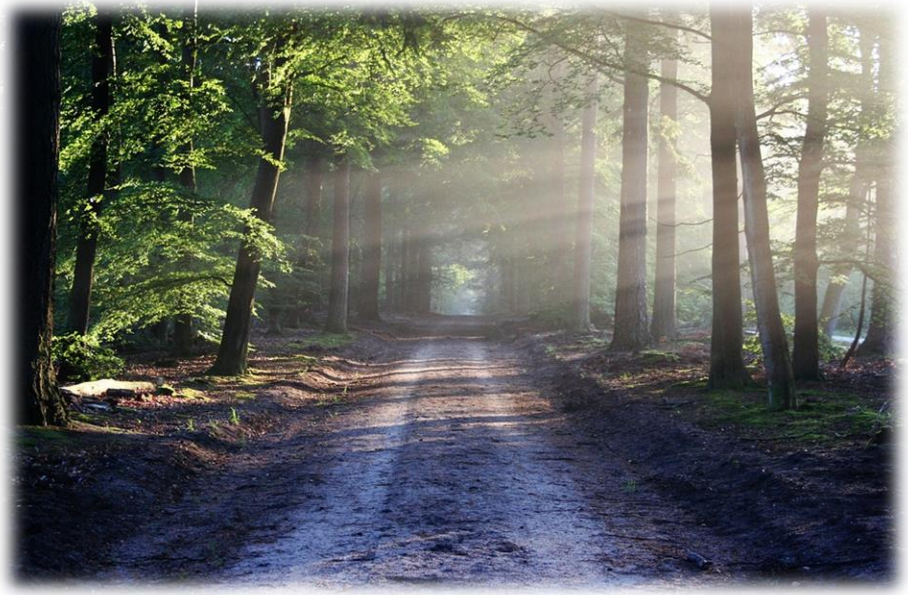


Image processing (7/7)

➢ Lighting Removal

Here are two simple and normal algorithm in light removal.

✓ Subtraction

$$R = L - I$$

✓ Division

$$R = 255 * (1 - I/L)$$

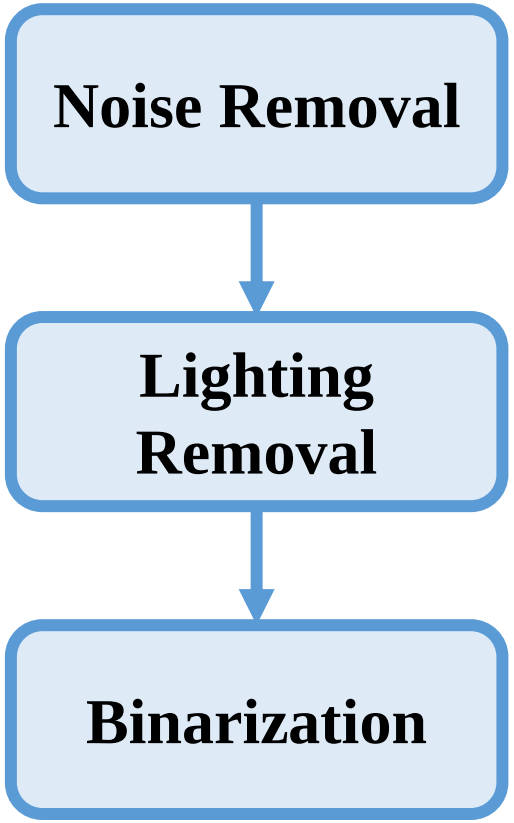
R : Removal Result

L : Lighting image

I : Original Image

★ Note that, it's very easy to understand, but remember **an image is a matrix data**.

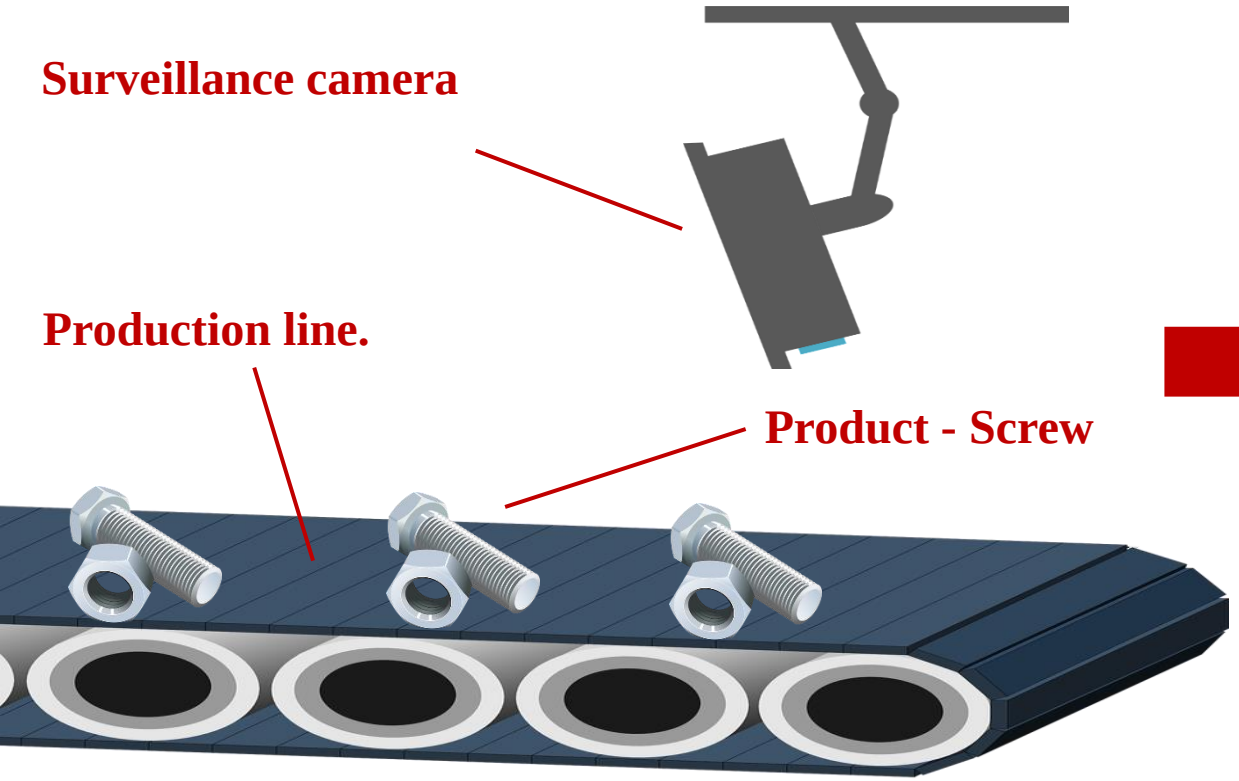
Automated Optical Inspection (AOI) (1/6)



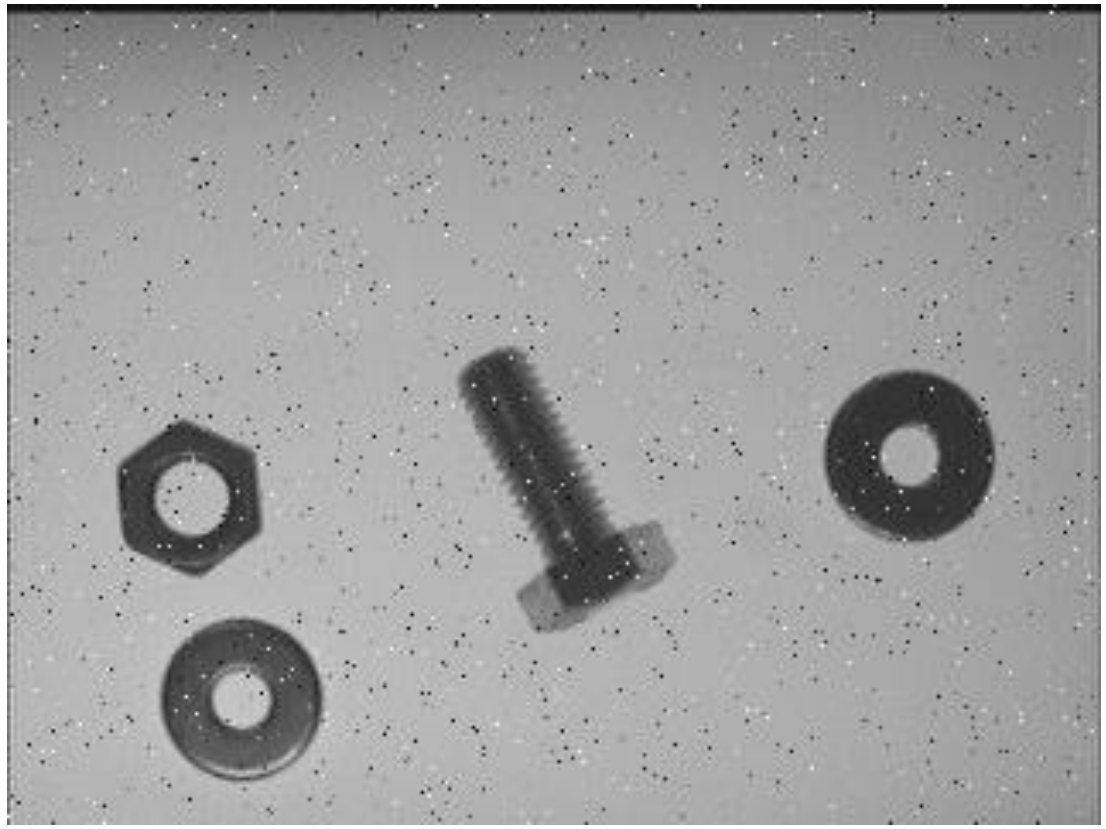
- ➢ Remove the Salt-pepper noise (dust, haze …etc.)
- ➢ Remove the light of background (high intensity information.)
- ➢ Using thresholding to make the object clearly.

- **Basic AOI flowchart**

Automated Optical Inspection (AOI) (2/6)



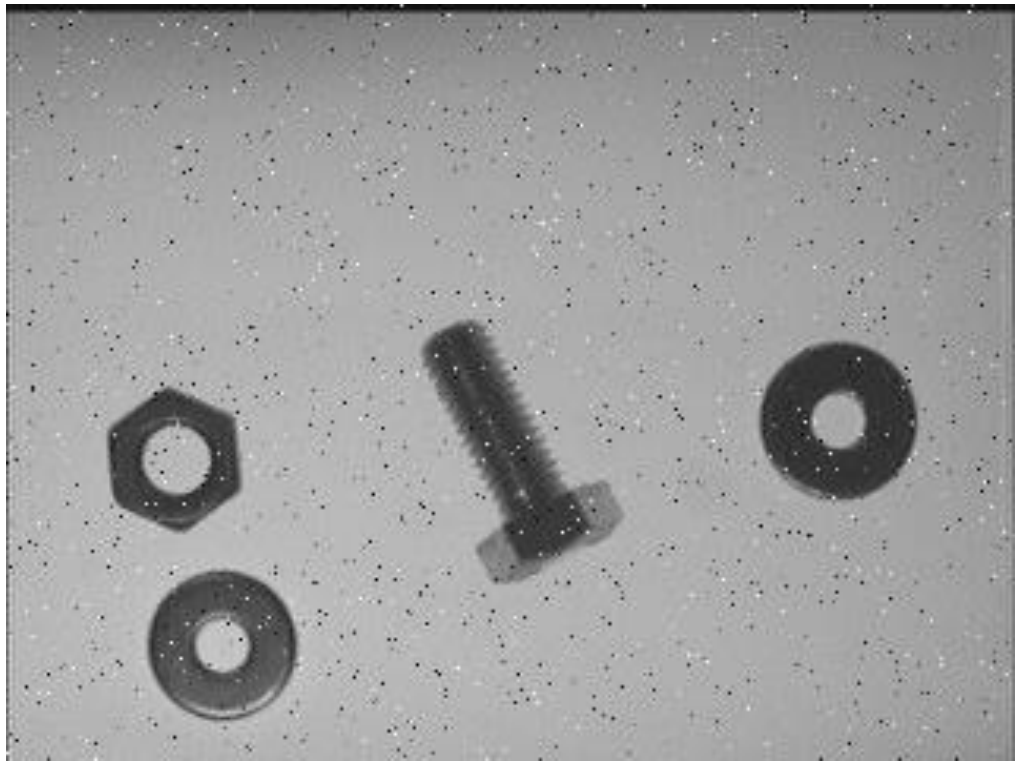
Common production line



Capture result

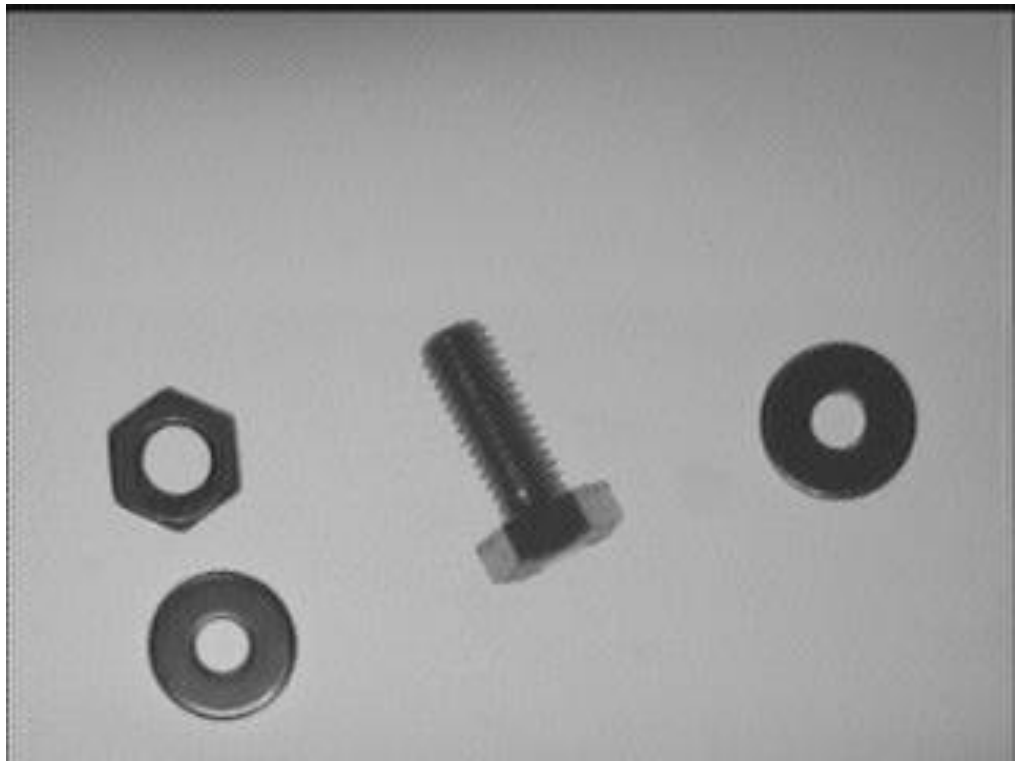
Automated Optical Inspection (AOI) (3/6)

➢ Noise Removal



Capture result with Salt-pepper

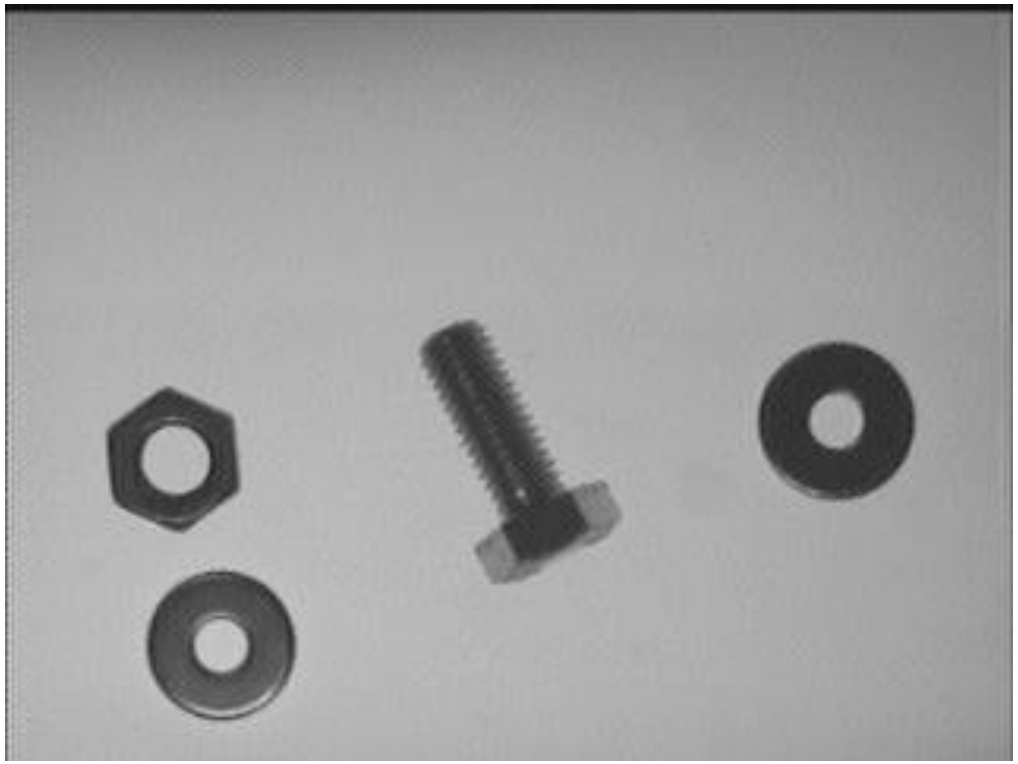
Median filter



Remove Salt-pepper result

Automated Optical Inspection (AOI) (4/6)

➢ Lighting Removal



Remove Salt-pepper result

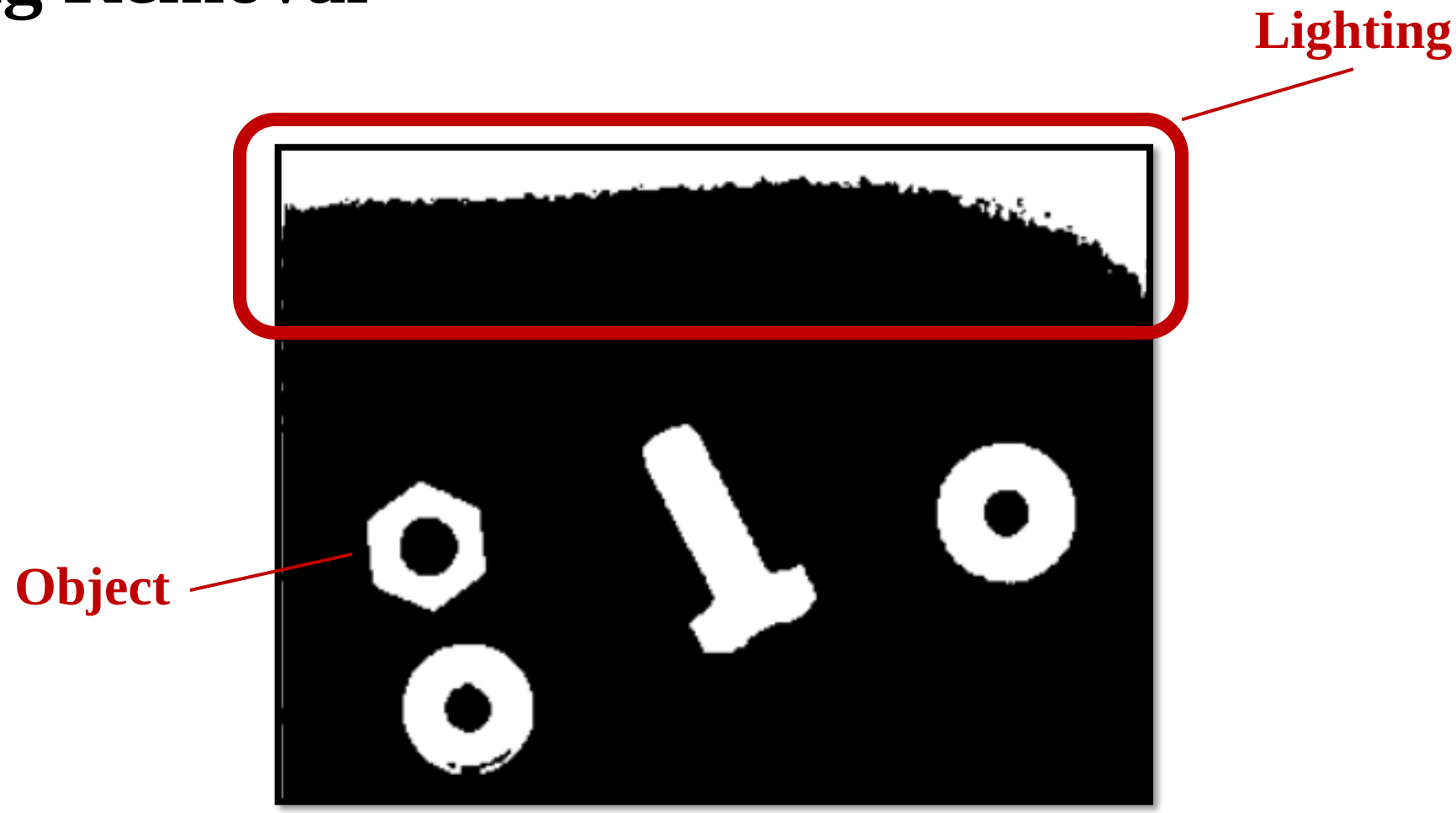
(Minus)

(Divided by)

Light

Automated Optical Inspection (AOI) (5/6)

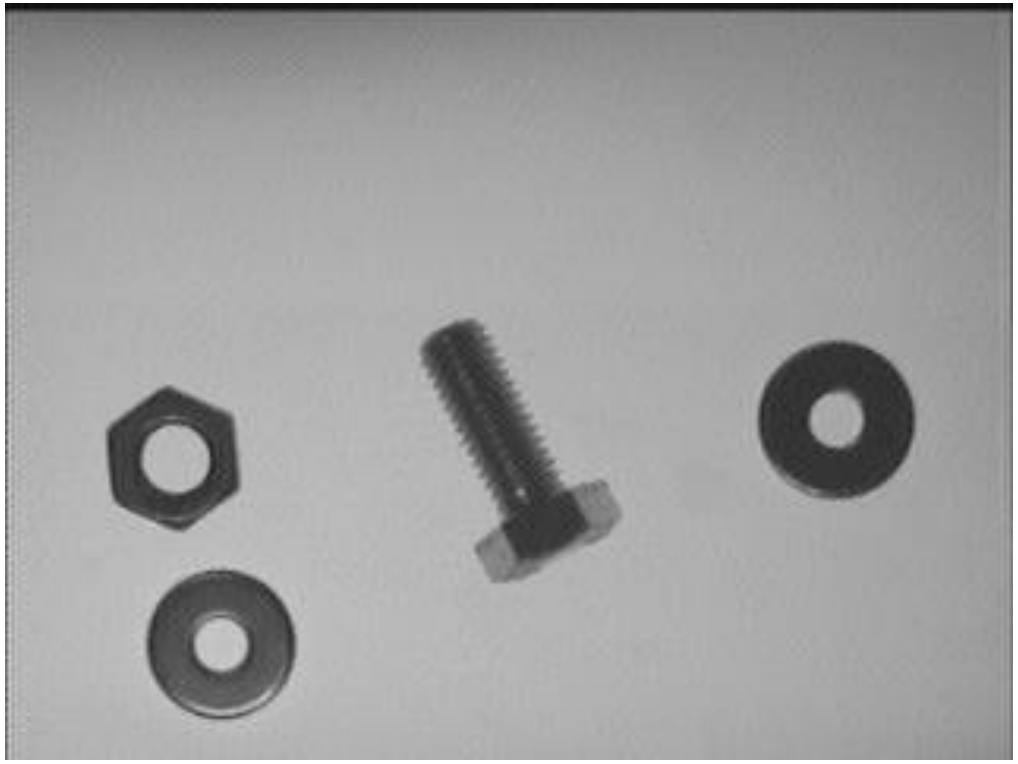
➢ Lighting Removal



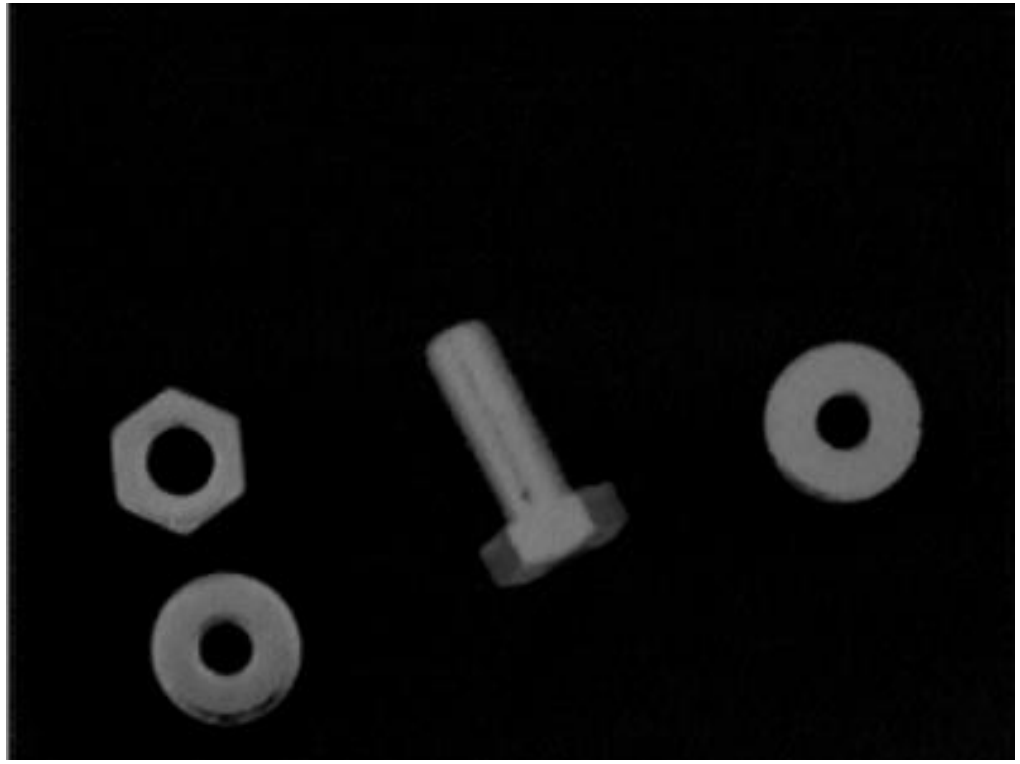
Thresholding result without Lighting Removal

Automated Optical Inspection (AOI) (6/6)

➢ Lighting Removal



Remove Salt-pepper result



Remove background light result

Demo

Practice

Exercise #2

Use the noised image on the NCUE cloud to complete the Basic AOI for using median filter, lighting Removal and giving a thresholding result.

- ✓ **Note:**

  .sln & *.ppt(or *.pptx) are necessary and compress in a *.rar file.

Thanks!

Any questions?