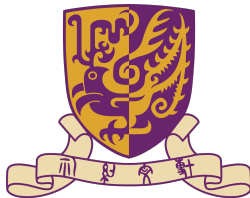# EIE4512 - Digital Image Processing

Week 3 Tutorial

Bin Zeng

zengbin@cuhk.edu.cn
School of Science and Engineering
The Chinese University of Hong Kong, Shen Zhen

January 23, 2019

Content

1. linear spatial filtering

2. non-linear spatial filtering

3. average smoothing VS gaussian smoothing

- Correlation
  - Correlation is the process of moving a filter mask over the image and computing the sum of products at each location
- Convolution
  - Similar to correlation except that the mask is first flipped both horizontally and vertically.
  - If filter is symmetric, then convolution is equivalent to correlation!

1. linear spatial filtering

Padded *f*

```
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
```

Origin $f(x, y)$

```
0 0 0 0
0 0 0 0      w(x, y)
0 0 1 0 0    1 2 3
0 0 0 0 0    4 5 6
0 0 0 0 0    7 8 9
```
(a)

(b)

Initial position for *w*

```
1 2 3 | 0 0 0 0 0 0
4 5 6 | 0 0 0 0 0 0
7 8 9 | 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
```
(c)

Full correlation result

```
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 9 8 7 0 0 0
0 0 0 6 5 4 0 0 0
0 0 0 3 2 1 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
```
(d)

Cropped correlation result

```
0 0 0 0 0
0 9 8 7 0
0 6 5 4 0
0 3 2 1 0
0 0 0 0 0
```
(e)

Rotated *w*

```
9 8 7 | 0 0 0 0 0 0
6 5 4 | 0 0 0 0 0 0
3 2 1 | 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 1 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
```
(f)

Full convolution result

```
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 1 2 3 0 0 0
0 0 0 4 5 6 0 0 0
0 0 0 7 8 9 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0
```
(g)

Cropped convolution result

```
0 0 0 0 0
0 1 2 3 0
0 4 5 6 0
0 7 8 9 0
0 0 0 0 0
```
(h)

2. non-linear spatial filtering

- ▶ Order-statistic filter
  - ▶ based on ordering (ranking) the pixels contained in the image area encompassed by the filter, and then replacing the value of the center pixel with the value determined by the ranking result.
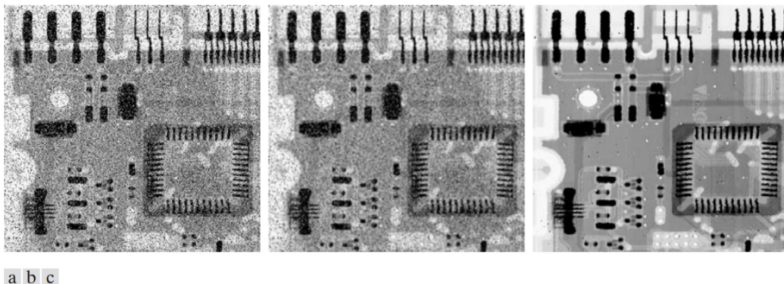 - ▶ median filter is the best-known filter in this category.
- ▶ MATLAB API: https: //ww2.mathworks.cn/help/images/ref/medfilt2.html

a b c

FIGURE 3.35 (a) X-ray image of circuit board corrupted by salt-and-pepper noise. (b) Noise reduction with a 3 × 3 averaging mask. (c) Noise reduction with a 3 × 3 median filter. (Original image courtesy of Mr. Joseph E. Pascente, Lixi, Inc.)

3. average smoothing VS gaussian smoothing