MANU2480

AUTONOMOUS SYSTEM

ROBOTIC PERCEPTION – Part 2

School of Science, Engineering and Technology, RMIT Vietnam

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Problem Statement

How to blur and to sharpen a greyscale image?

Image Filtering

Filter in signal conditioning and data acquisition.

Filter is a frequency domain processing. It is a process of accepting or rejecting certain frequency components.

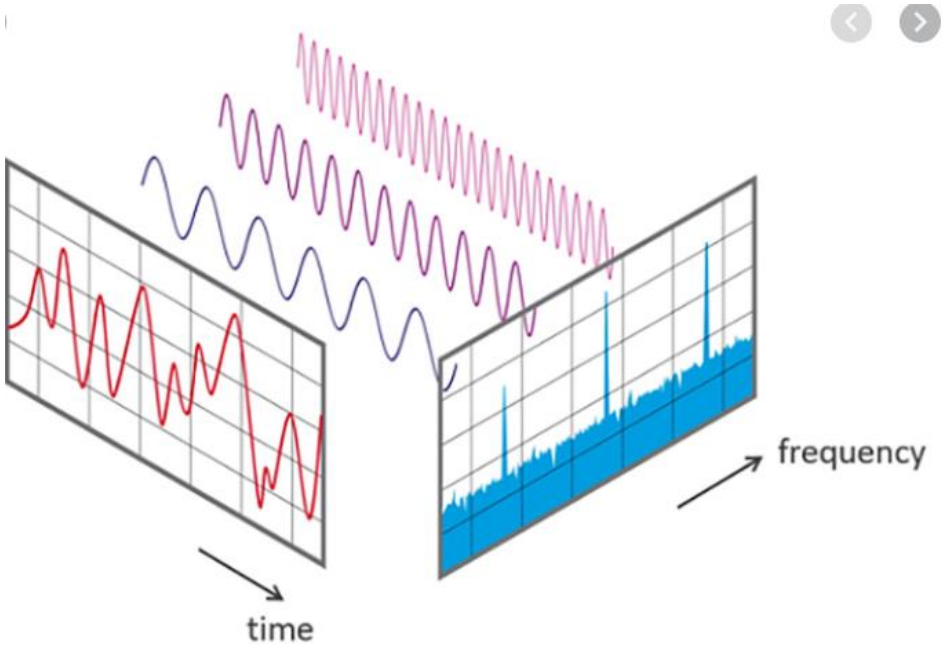

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Image Filtering

For Example:

- A low pass filter that passes low frequencies is called a low-pass filter.
- A high pass filter that passes high frequencies is called a high-pass filter.

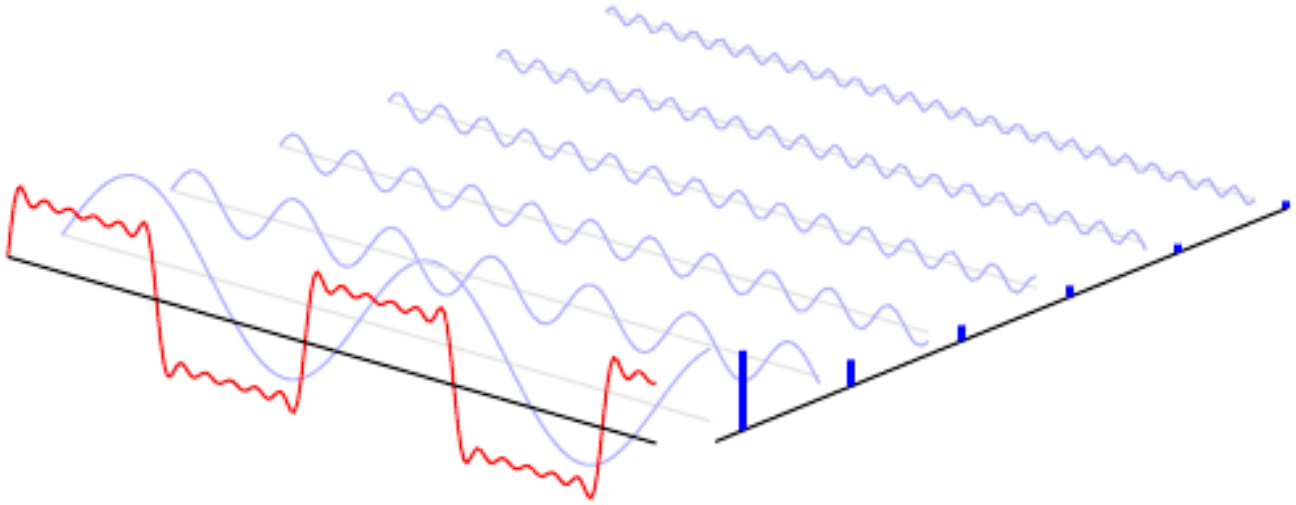
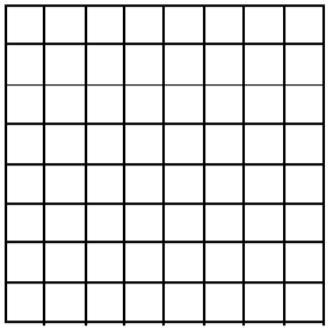


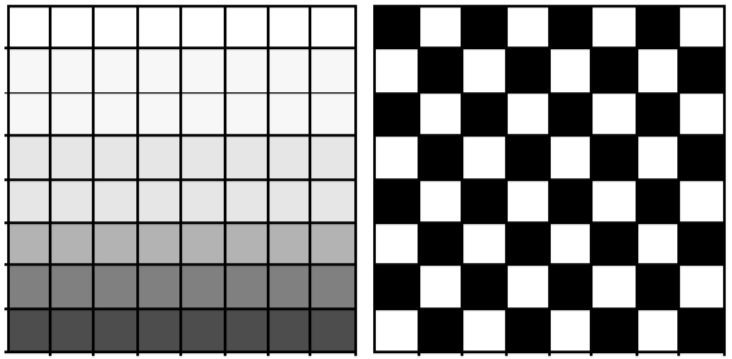
Image Filtering

Image Frequency in Image Processing

- The image frequency (also called spatial frequency) can be defined as changing in gray level values with distance.
- The high-frequency coefficients are defined by large changes in the gray level value over a small distance.
- The low-frequency coefficients are defined by small changes in the gray level value over a large distance



zero spatial frequency



low spatial frequency *high spatial frequency*

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Image Filtering

Filter in Image Processing

In Image Processing, spatial frequency filters (also called spatial filter, or **masks** or **kernels**) are used instead of normal frequency filters used in signal processing. There are also **low-pass filter** and **high-pass filter**.

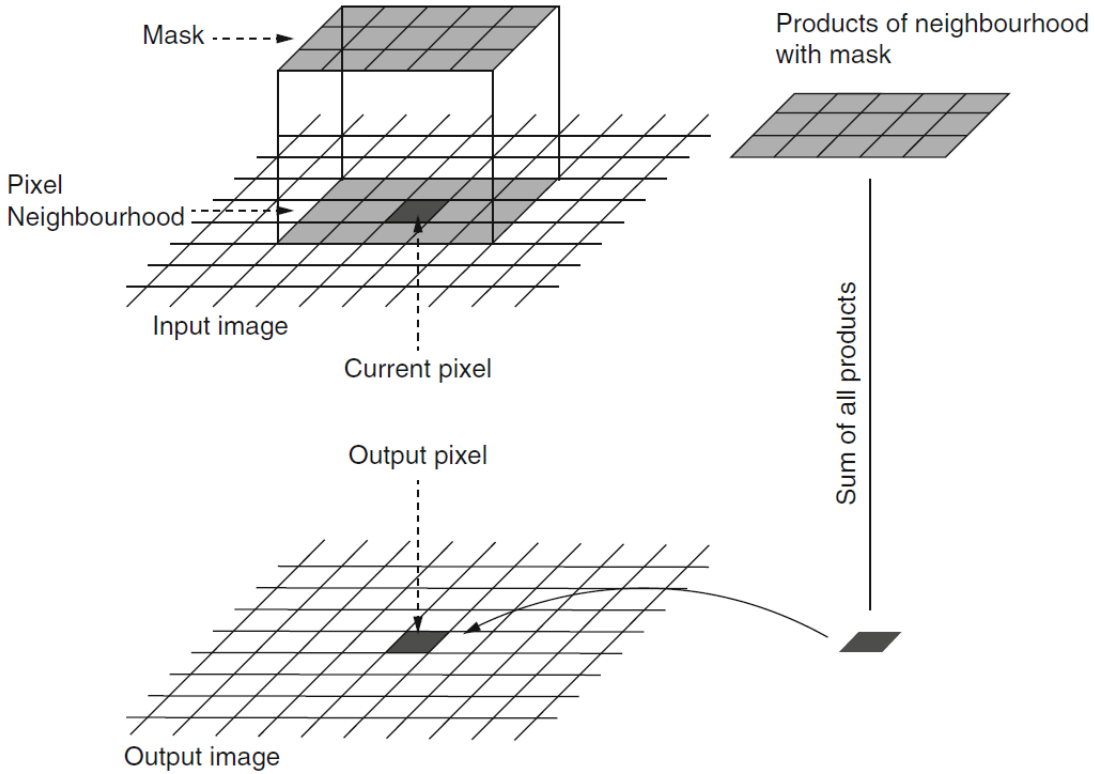
Image Filtering

Filter in Image Processing

- **The low-pass filter** passes low-frequency coefficients and removes high frequency coefficients. This filter removes noise and edges from the image.
- **The high-pass filter** passes high-frequency coefficients and removes low-frequency coefficients. This filter removes background and skin texture information from the image.
- The low-pass filter is known as the smoothing filter **and the high-pass filter is known as the sharping filter.**

Image Filter

In terms of “Maths”, the combination of the **mask** and **operating function** is called the image filter.

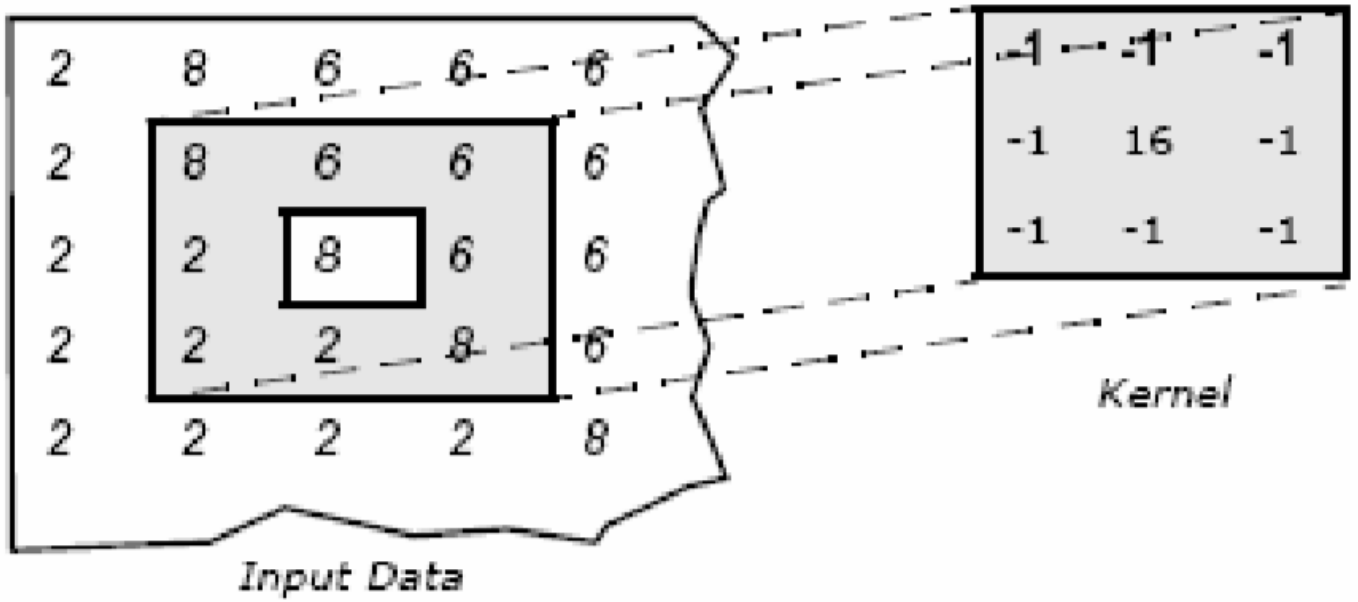


Linear Filter

If the filter gives a new gray level value using a linear operation, it is called a **linear filter**. For spatial filtering, **three basic steps** are required for image enhancement:

- Position the mask over the current pixel.
- Form all products of filter elements with the corresponding elements of the neighborhood.
- Add up all the products.

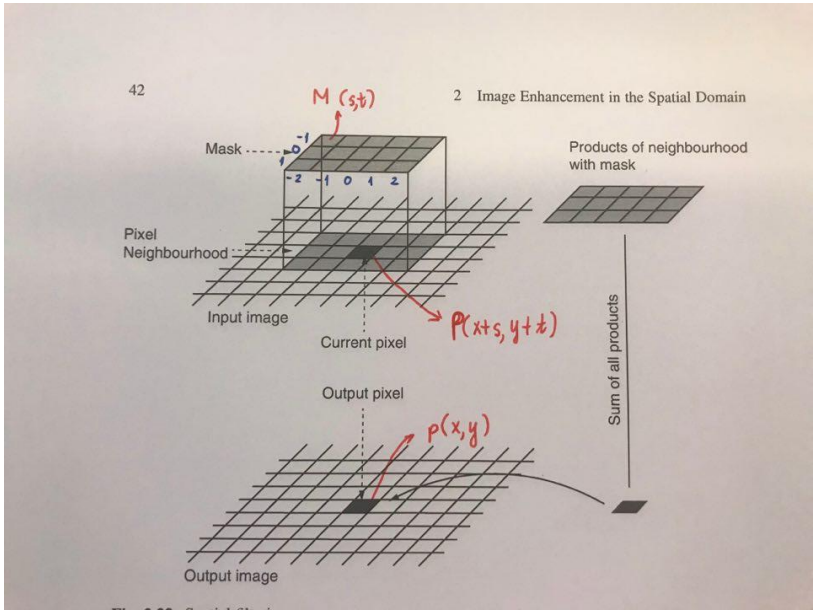
Image Filter

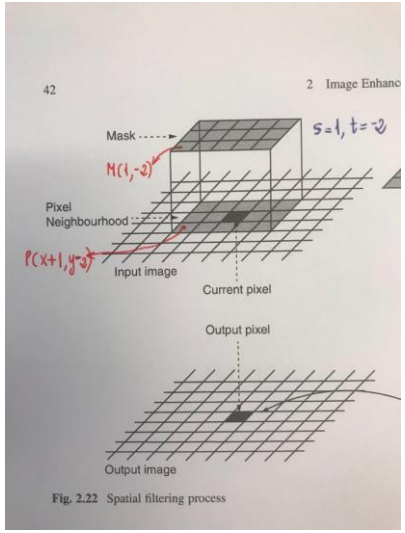


Linear Filter

- Suppose a 3 x 5 mask is used and a processes pixel value can be gained using the following equation:

$$p(x,y) = \sum_{s=-1}^{1} \sum_{t=-2}^{2} M(s,t)P(x+s,y+t)$$





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Linear Filter

- In general, given the a x b mask, a processes pixel value can be gained using the following equation:

$$p(x,y) = \sum_{s=-a}^{a} \sum_{t=-b}^{b} M(s,t)P(x+s,y+t)$$

Linear Filter

- We would not usually process the pixel along the edges of a given image.
- If we would like to process these pixels, we can assume there are “extra” pixels outside the edge which have the value of 0 and follow the same procedure.

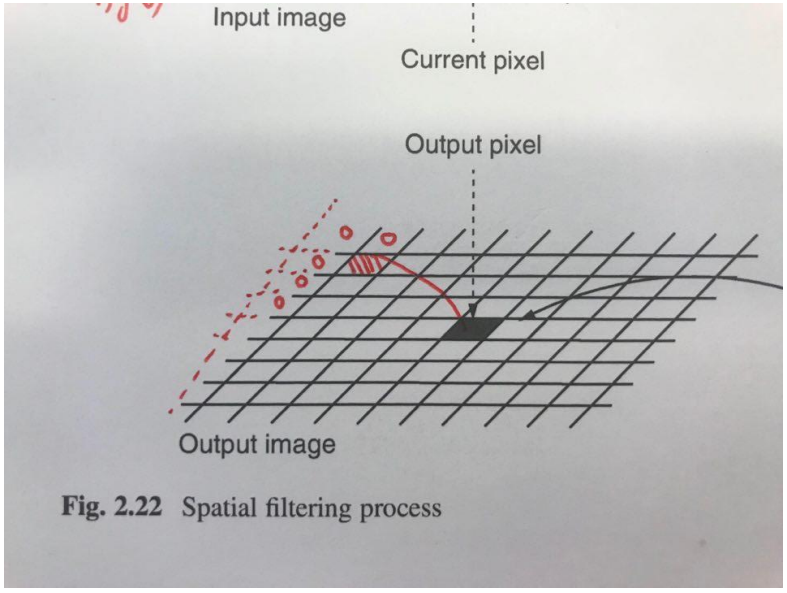
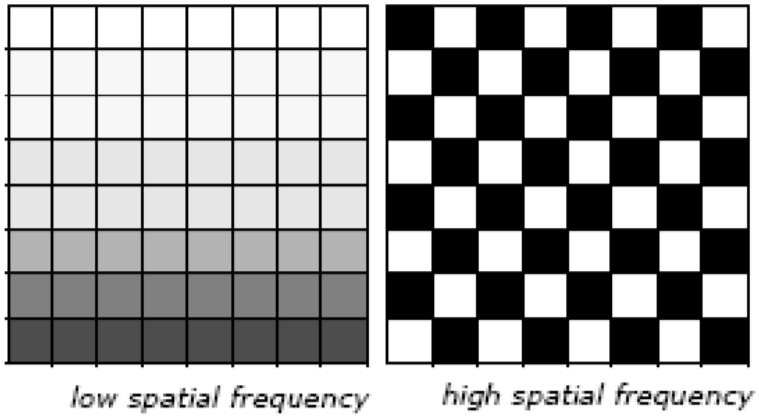


Fig. 2.22 Spatial filtering process

Low-Pass Averaging Filter

- The idea of low-pass average filtering is that it replaces the gray level value of every pixel with the average gray level value of its neighborhood pixels. The resultant image has less sharp transitions in the gray level.
- **A standard averaging filter** yields the standard average of all the pixels in the mask. For example, a 3x3 mask of this kind are presented as:

$$M(s,t) = \begin{bmatrix} \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \\ \frac{1}{9} & \frac{1}{9} & \frac{1}{9} \end{bmatrix}$$



Low-Pass Averaging Filter

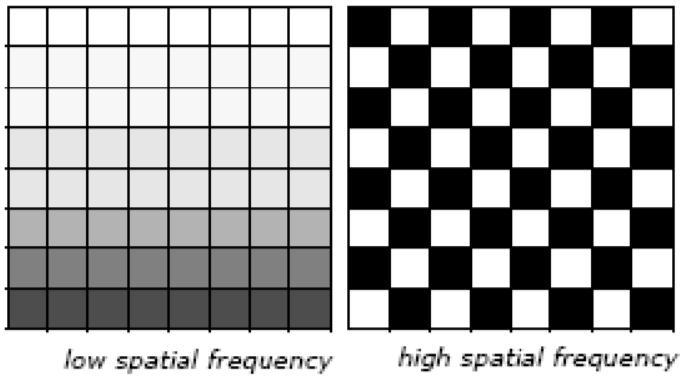
A weighted averaging filter yields the weighted average of all the pixels in the mask (also called Gaussian smoothing). For example, a 3x3 mask of this kind is presented as:

$$M(s,t) = \begin{bmatrix} \frac{1}{16} & \frac{2}{16} & \frac{1}{16} \\ \frac{2}{16} & \frac{4}{16} & \frac{2}{16} \\ \frac{1}{16} & \frac{2}{16} & \frac{1}{16} \end{bmatrix}$$

High-Pass Averaging Filter

- The high-pass filter is used in the sharping process with the principle objective is to highlight fine details or enhance details that have been blurred. For example, a 3x3 mask used for high-pass filtering is shown as below.
- As we can see, the sum of the elements of the high-pass mask must equal zero. This is because when we place the mask on the low-frequency region (i.e., over an area of constant gray level), the result must be nearly zero.

$$M(s,t) = \begin{bmatrix} -1 & -1 & -1 \\ -1 & 8 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$



Thank you for your attendance :D

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Reference

- *MATHWORKS official tutorial.*
- *Lecture slides from RMIT Melbourne Autonomous System course, delivered by Prof Reza Hoseinnezhad.*
- *Wheeled Mobile Robotics. From Fundamentals Towards Autonomous Systems.*
- *Digital Image Processing using Scilab.*

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