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Signal Processing

Winter semester 2018/2019

Lab 2
2D Convolution and its Application in Image Processing

Discrete Convolution of two Signals

1.1. Convolve the image matrix

$$\begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 5 & 4 & 3 & 4 & 5 \\ 5 & 4 & 3 & 4 & 5 \\ 5 & 4 & 3 & 2 & 1 \end{bmatrix}$$

With the kernel

$$\begin{bmatrix} 1 & 1 & 1 \\ 2 & 2 & 2 \\ 1 & 2 & 1 \end{bmatrix}.$$

Calculate the convolution only where kernel and image overlap entirely.

1.2. Detect the edges via convolving the following image matrix

$$\begin{bmatrix} 1 & 1 & 1 & 9 & 9 & 9 & 1 & 1 & 1 & 9 & 9 & 9 & 1 & 1 & 1 \\ 1 & 1 & 1 & 9 & 9 & 9 & 1 & 1 & 1 & 9 & 9 & 9 & 1 & 1 & 1 \\ 1 & 1 & 1 & 9 & 9 & 9 & 1 & 1 & 1 & 9 & 9 & 9 & 1 & 1 & 1 \\ 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 \\ 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 & 9 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

With both 3x3 Sobel kernels.
Calculate the convolution only where kernel and image overlap entirely.

Practical Applications of Filtering in Digital Image Processing

Select any kind of digital image. It might be taken by your camera for example and should contain some fine structures. Make sure, the image is not too big, i.e. not more than 1000 x 1000 pix, better 500 x 500 pix only.

2.1 Start the Matlab Image Smoothing Filter Tools by F. Ledda (see access below).
Apply the following filters to your image.
At least try two different sizes of each filter mask. Compare and discuss results in detail!

- Box filter (in the tool named Average Filter)
- Gauss filter
- Median filter

2.2 In addition to the filter operations done so far, also use the PhotoShop / IrfanView tool to get a first impression on the following filter operations. Again, discuss results!

- Edge detection
- Image sharpening

Matlab Tool: Image Smoothing Filter Tools by F. Ledda
http://www.mathworks.com/matlabcentral/fileexchange/42962-image-smoothing-filter/content/Smoothing%20Filter/ImageSmoothingFilter.m

Understanding

3.1. Both, rank filters and convolutional filters make use of a sliding window approach. Nevertheless, a rank filter cannot be realized by convolution. Why?

3.2. What is the advantage of a Binomial Filter compared to a Gaussian Filter?

3.3. Why is a Binomial Filter or Gaussian Filter a better smoothing filter than a Box Filter?

3.4. Why should you use a Median Filter for eliminating Binary Noise (instead of a Gaussian Filter)?

Optional: Programming

Load the Matlab default image 'cameraman.tif' and convolve it with the [5x5] Binomial Filter.
Implement the filtering in the spatial domain and the frequency domain.
Useful matlab functions: fft2(), fftshift(), ifft(), imfilter(), conv().
Hints:
For representing signals in the frequency domain, the values are scaled on a logarithmic scale and centered via fftshift(): fftshift(log(1+abs(image_in_frequency_domain)))
abs() is used for extracting the amplitude.

Deadline: Tuesday, 19th December 2018

Please, submit only one report per group. Submission in digital manner as PDF document). Send report via mail to dominik.laupheimer@ifp.uni-stuttgart.de.
Please, comply with the following naming convention: SigProc-Lab2-NAME1-NAME2.pdf