Exercise Image Processing

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Sheet 5

In this exercise we cover the chapters *convolution*, *correlation*, and *linear and nonlinear filter design*. The questions are small-part and can be seen as examples of potential exam problems. Also use the formulary for the exam to work through the problems.

Task 5.1: Convolution and Correlation

5.1a)

What condition must a 2D convolution mask satisfy to be separable?

5.1b)

Specify how many arithmetic operations (specify additions/subtractions and multiplications/divisions separately) can be saved with a separable convolution compared to a non-separable convolution depending on the mask size ($K \times L$).

5.1c)

What is the difference between convolution and correlation?

5.1d)

What condition must a convolution mask satisfy for the result to correspond to a correlation?

5.1e)

Name two different ways of border handling when convolving an image?

Task 5.2: Linear Filters

5.2a)

What properties should an ideal smoothing filter have?

5.2b)

Name three different smoothing filters and one property common to all of these filter masks?

5.2c)

Specify the result of the box filter for the following image area:

6	4	0
9	1	7
3	5	2

5.2d)

How many summations and how many multiplications are saved for an r times convolution with a 1×2 rectangular filter compared to a convolution with a 1D binomial filter of order r per pixel?

5.2e)

What properties should an ideal difference filter have?

5.2f)

What filter results when the following two filter masks are **convolved**:

$$\begin{array}{|c|c|c|} \hline -1 & 1 & 0 \\ \hline \end{array} \quad * \quad \begin{array}{|c|c|c|} \hline 1 & 0 & -1 \\ \hline \end{array}$$

5.2g)

Which 2D filter mask results, for the following separable filter:

$$\begin{array}{|c|} \hline 1 \\ \hline -1 \\ \hline 1 \\ \hline \end{array} \cdot \begin{array}{|c|c|c|} \hline 1 & 2 & 1 \\ \hline \end{array}$$

5.2h)

In a 2D regularized derivative, does it make a difference whether you first average along one direction and then differentiate along the orthogonal direction, or reverse the order? Justify your answer.

5.2i)

Various filters are given in the table. Assign the order of the derivatives involved.

	symmetric difference	Laplace-Filter	Sobel-Filter	LoG-Filter	DoG-Filter
1st order derivative					
2nd order derivative					

Task 5.3: Nonlinear Filters

5.3a)

Which rank order filter applied to a binary image corresponds to which set operation.

	Minimum-Filter	Median-Filter	Maximum-Filter
Dilation			
Erosion			

5.3b)

Explain the morphological operator: opening.

5.3c)

What feature can you extract in an image when you subtract the result of an erosion with a 3×3 mask from a dilation with a 3×3 mask?

5.3d)

Specify the result of the median filter for the following image area:

9	13	34	39	16
43	31	52	17	16
6	4	0	3	2
9	1	7	8	5
3	5	2	12	11