Zürcher Hochschule
für Angewandte Wissenschaften

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Digital Image Processing
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Exercise Sheet 3

1 γ-Correction

1. If we were to employ γ-correction to brighten up an image, would γ the be greater or smaller than one?

2. Plot the transformation function that maps the old gray levels to the new gray levels for various values of γ, with $0.1 \leq \gamma \leq 10$. Do you see any symmetries?

3. Does γ-correction change the histogram of an image? If yes, briefly explain why and how.

2 Histogram Stretching

Assume we are looking at a three-bit grayscale image. It only features gray levels from 2 to 6 although gray levels between 0 and 7 are possible. The histogram looks as follows

Gray Level	0	1	2	3	4	5	6	7
# Pixels	0	0	50	60	50	20	10	0

In order to use the full gray scale range you apply *histogram stretching*. What does the histogram look like after this operation? **Hint:** Start by writing down the equation that maps the old gray level to the new gray level. It is a linear transformation that maps the lowest occuring gray level to 0 and the highest occuring gray level to 7.

3 Histogram Equalization

Assume we are looking at a three-bit grayscale image featuring gray levels from 0 to 7. The histogram looks as follows

Gray Level	0	1	2	3	4	5	6	7
# Pixels	790	1023	850	656	329	245	122	81

What does the histogram look like after *histogram equalization*? **Hint:** It might be helpful to sketch the histogram and the distribution funtion.

4 Filter Concatenation

In order to detect edges in an image you first apply a 3×3 low-pass filter, and then a 3×3 Laplace filter.

1. Sketch a possible filter mask for each of these two filters. There are several possible solutions.

2. What happens if you change the order of the filters (first Laplace, the low-pass)?

3. **For those who dare:** Would it be possible to integrate both operations (Laplace & low-pass) in a single filter? If yes - what would it look like?

5 Averaging Filter

Figure 1 shows a periodic pattern of black bars on white background. Each bar has a width of 5 pixels, the distance between two adjacent bars is 20 pixels. This image is now subject to an averaging filter operation with various kernel sizes.

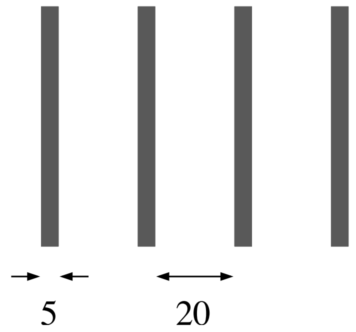

Figure 1: Periodic pattern.

1. What happens to the image and the pattern, when the kernel size is 3×3, 23×23, 25×25?

2. **For those who dare:** What happens if you increase the kernel size to 45×45?

Solutions

Exercise 1 – γ-Correction

1. $\gamma < 1$
2. That's shown in the lecture slides
3. Yes. It (possibly) creates new gray values and changes the rate of occurence.

Exercise 2 – Histogram Stretching

Gray Level	0	1	2	3	4	5	6	7
# Pixels	50	0	60	0	50	20	0	10

Exercise 3 – Histogram Equalization

Assume we are looking at a three-bit grayscale image featuring gray levels from 0 to 7. The histogram looks as follows

Gray Level	0	1	2	3	4	5	6	7
# Pixels	0	790	0	1023	0	850	985	448

Exercise 4 – Filter Concatenation

1.

$$\text{low-pass: } h = \frac{1}{9}\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}, \text{ Laplace (isotropic): } h = \begin{bmatrix} 1 & 1 & 1 \\ 1 & -8 & 1 \\ 1 & 1 & 1 \end{bmatrix}$$

2. Convolution is (as you know from previous lectures) commutative. Therefore you obtain the same result.
3. Yes. If you have the solution you can double check it with Python.

Exercise 5 – Averaging Filter

1. With increasing kernel width the black bars get broader. For a kernel size of 23×23 the bars are indistinguishable, and for a kernel size of 25×25 you obtain a uniformly gray image.
2. That's a brain teaser. If you have the solution you can double check it with Python by simply creating such an image and applying the filter (all in all less than 10 lines of code).