Life Sciences und
Facility Management

ICLS Institut für
Computational Life Sciences

ADLS, Image and Signal Processing, Midterm Exam II

Date: 29. April 2024
Lecturer: Norman Juchler

- Enter your name legibly below.
- Permitted aids: Writing utensils, two A4 pages of summary, calculator, dictionary
- Duration of exam **30 min**
- All sketches, calculations, derivations and considerations must be written on these sheets (front and back) and handed in. Additional sheets are not allowed.
- Provide answers in English
- Clearly cross out invalid answeres and results. If it is unclear which result applies, no points are awarded.
- Do not write with pencil, colored pencil or other erasable pens

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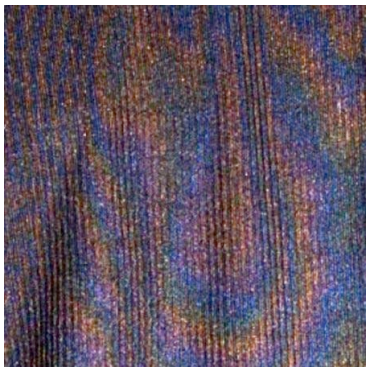
Family name: **First name:**

Exercise	1	2	3	4	Total
Maximum	10	9	10	7	36
Result					

Grade: _____ **Good luck!**

Question 1

10 P.



a) **Color distortion** (3 P. possible)

The picture above shows a close-up of a fabric with an unfavorable camera setting. Explain the nature of this distortion. What is this effect called?

b) **Image quality attributes** (3 P. possible)

List three different aspects that influence the quality of a picture. Provide a name for each aspect or concept and describe it in one to two sentences.

c) **Color spaces** (3 P. possible)

RGB is the most common color space in digital image processing. Nevertheless, many other color spaces exist.

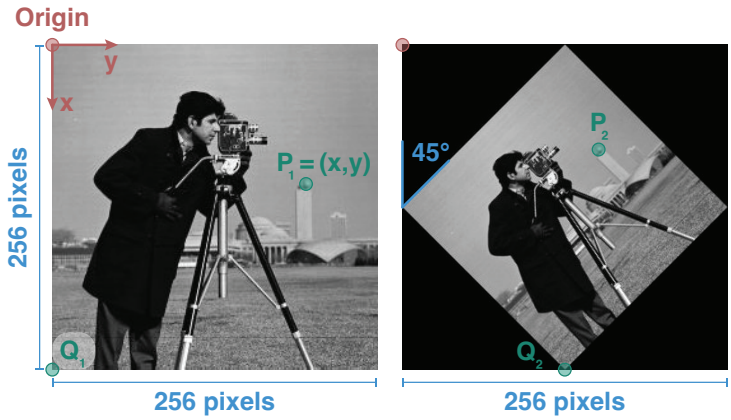
- Name three alternative color spaces. If you use acronyms, state what each letter means.
- Is RGB not good enough? Why are there other color spaces? Name at least two reasons.

d) **Memory footprint** (1 P. possible)

Suppose we are working with an RGBA image with four channels, 16-bit image depth and a resolution of 1920×1080px (full HD). How much memory (in bytes) is required for this image? Recall that 1 byte $= 8$ bits.

Question 2

9 P.



a) **Affine transformations** (7 P. possible)

Take a look at the image above. The image is 256x256 pixels in size and the angle of rotation is $+45°$. Answer the following questions:

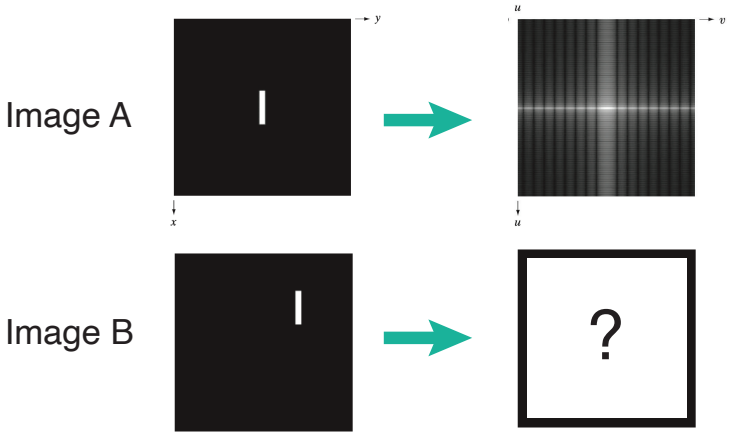
1. What transformations are required to convert the left image into the right image. Suggest one possible sequence of elementary transformations to achieve this. Specify the transformations in words.
2. How many such sequences are possible?
3. Write the affine transformation matrix $A \in \mathbb{R}^{3\times3}$ as a product of elementary transformations. Specify the parameters of the elementary transformation matrices correctly, but you do not have to calculate A explicitly.
   Note: The origin of the coordinate system is in the top left corner!
4. The point $Q_1 = (256, 0)$ will be mapped to $Q_2 = (256, 128)$. Can you confirm this with your formula for A?

b) **Homogeneous coordinates** (2 P. possible)

If we have a point $P = (x, y)$, what is its representation using homogeneous coordinates? What is the reason for using homogeneous coordinates?

Question 3

10 P.



a) **Translation and amplitude spectrum** (2 P. possible)

In the first row of the above figure, you can see the (logarithmic) amplitude spectrum for input image A. What happens to the amplitude spectrum if the input image is shifted by $t = (\Delta x, \Delta y)$ as seen in image B? Explain!

b) **Fourier spectrum**, characteristics (4 P. possible)

Assume that the input image has width w and height h. Answer the following questions about the DFT and the amplitude spectrum of that image.

- What are width and height of the resulting image that represents the amplitude spectrum?
- Where can we typically read the DC component?
- Are there any symmetries for real-valued input images? If yes, which ones?
- What is the largest spatial frequency that we can read from the spectrum?

c) **Fourier spectrum**, implementation (4 P. possible)

Write a Python function `compute_spectrum(img)` that takes an image as input, calculates its amplitude spectrum and displays it. The code does not have to be functional, but the relevant steps should be recognizable. Comment on what happens in each step.

Question 4

7 P.

Image A

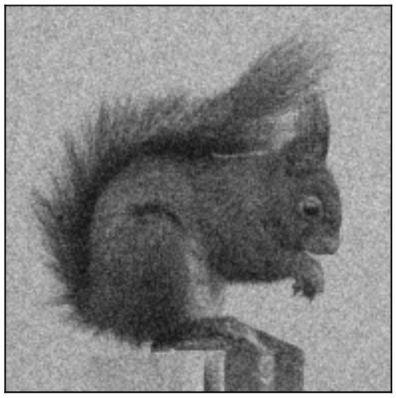


Image B

a) **Edge detection** (5 P. possible)

Assume you want to identify the edges of the above image A using two Sobel filters (in x- and y-direction).

- Which are the steps to get the results?
- For every step, write down the corresponding Python function / expression (use numpy and scipy only).
- Are any kernels involved? How would they look like?

b) **Edge detection and noise** (2 P. possible)

Now, assume that you want to extract the edges for image B. Which are your best options in this case?