KIT Department of Informatics
Institute for Anthropomatics and Robotics (IAR)
High Performance Humanoid Technologies (H^2T)

Robotics I, WS 2024/2025

Exercise Sheet 6

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Date: 29. January 2024

Exercise 1 (Color representation)

1. Transform the following colors specified in the RGB modeland into the HSI format.
   i.) (120, 80, 210)
   ii.) (0, 150, 130)
2. A robot observes at a pack of cereal in a windowless laboratory. Someone turns the light a little brighter.
   i.) Do the R, G or B values of the cereal package change?
   ii.) Do the H, S or I values of the cereal package change?
3. The robot observes the pack in a kitchen with windows. Outside, a cloud pushes in front of the sun.
   i.) Do the R, G or B values of the cereal package change?
   ii.) Do the H, S or I values of the cereal package change?

Exercise 2 (Camera Modell)

Given a pinhole camera in positive position with focal length $f = 20mm$:

1. You use it to photograph a building from a distance of 350 meters. In the picture, the building is $0.8mm$ high. How high is the actual building?

2. You are taking a photo of Cologne Cathedral, which is known to be $100\frac{\pi}{2}m$ high, from the opposite bank of the Rhine from a distance of $800m$. In your photo, the cathedral is 314 pixels high. How many pixels per millimeter does the camera have?

Exercise 3 (Filters in Image Processing)

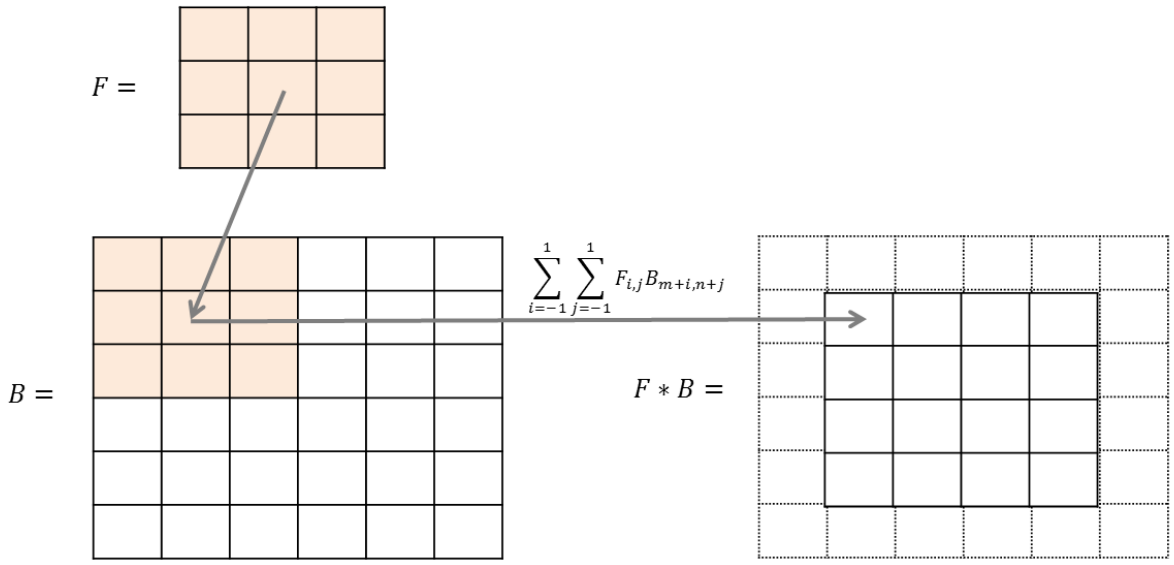

Figure 1: Filtering: 1) The filter matrix is placed over the original image. 2) Overlaying pixels are mupltiplied and the products are added. 3) The result forms the pixel value of the filterd image at the position of the filter. The edge pixels of the resulting image can be ignored in this task.

Given the following gray scale image B:

$$B = \begin{pmatrix} 20 & 20 & 20 & 20 & 40 & 40 & 40 & 40 & 30 & 30 & 30 \\ 20 & 20 & 20 & 20 & 40 & 40 & 40 & 40 & 30 & 30 & 30 \\ 20 & 20 & 20 & 20 & 40 & 40 & 40 & 40 & 30 & 30 & 30 \\ 50 & 50 & 50 & 50 & 50 & 50 & 50 & 50 & 20 & 20 & 20 \\ 20 & 50 & 50 & 50 & 50 & 50 & 50 & 50 & 20 & 20 & 20 \\ 20 & 20 & 50 & 50 & 50 & 50 & 50 & 50 & 20 & 20 & 20 \\ 20 & 20 & 20 & 50 & 50 & 50 & 50 & 50 & 20 & 20 & 20 \end{pmatrix}$$

1. Calculate the result of filtering B with a Prewitt-X Filter
2. Calculate the result of filtering B with a Prewitt-Y Filter

Exercise 4 Threshold Segmentation

1. In the image in Figure 2 an object should be detected. The image has already been converted to a greyscale image and the intensity values (0 ... 255) are denoted on the pixels. For segmentation, threshold segmentation is applied with a threshold of $T = 51$. Show the result of the segmentation by filling the pixels in Figure 2 (right).

255	212	74	181	176	176	196	171	156
181	219	23	135	163	56	46	69	56
186	148	79	186	230	163	64	54	84
166	237	69	179	166	69	120	112	245
48	194	194	179	107	117	99	87	43
222	5	186	163	115	77	105	46	71
207	186	10	13	41	48	43	54	201
189	196	89	64	128	71	89	74	54

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189	196	89	64	128	71	89	74	54

Figure 2: Image which should be segmented (left). Use the right image to show the resulting segmentation.

2. How can the color information of the segmented object be preseved after segmentation.

Exercise 5 (Iterative Closest Point (ICP))

The point cloud $P = \{p_0, p_1, p_2\}$ shown in Figure 3 is to be registered with the triangle $V = \{v_0, v_1, v_2\}$ using the *Iterative Closest Point (ICP)* algorithm.

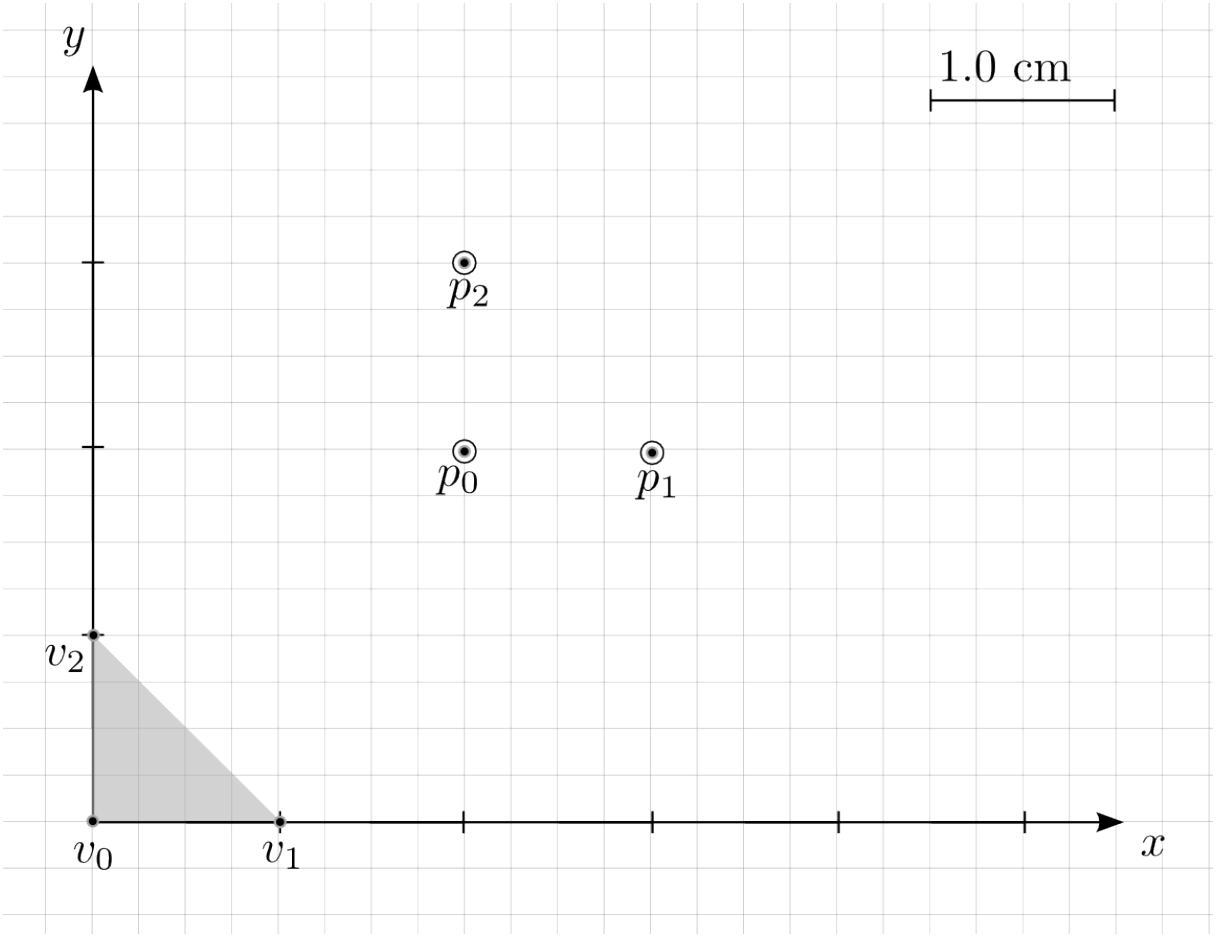

Figure 3: Point cloud $P = \{p_0, p_1, p_2\}$ and triangle $V = \{v_0, v_1, v_2\}$

1. Setup the error function F_T for the ICP-algorithm
2. To solve the problem the ICP-algorithm is to be applied using the steepest gradient approach. Determine the simplified error function.

$$F_T{}' = \left(\|v_0 - p_0\|\right)^2 .$$

3. For the ICP algorithm from the second part of the task, specify the function that approximates V to P with a step size α. Draw the first two iterations for $\alpha = 0.25$ in Figure 3.