Machine Vision, exam 9.3.2020

You may write your answers in Finnish or English.

1. Briefly explain the following terms (6 p)
   (a) Depth of field
   (b) HSV color space
   (c) Diffuse reflection
   (d) Confusion matrix
   (e) Local descriptor
   (f) Perspective-3-point (P3P) problem.

2. Describe the main principles of the following and give one example of their usage:
   (a) Image segmentation. (2 p)
   (b) Optical flow. (2 p)
   (c) Structure from motion. (2 p)

3. Stereo imaging

   Two pinhole cameras observe a 3D point $\mathbf{P} = (X, Y, Z)^\top$ from two different viewpoints. The camera projection matrices are

$$\mathbf{C} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix} \quad \mathbf{C}' = \begin{bmatrix} 1 & 0 & 0 & 1 \\ 0 & 0 & -1 & 1 \\ 0 & 1 & 0 & 1 \end{bmatrix}$$

   The coordinates of the 2D point in the first and second image are $\mathbf{p} = (-\frac{1}{2}, \frac{1}{2})^\top$ and $\mathbf{p}' = (0, -\frac{1}{2})^\top$, respectively.

   (a) Compute the 3D coordinates X, Y and Z. (**Hint:** Form a linear system of equations using the projection matrices and homogeneous coordinates. You can find the solution by hand.) (3p)

   (b) The essential matrix between the views is

$$\mathbf{E} = \begin{bmatrix} 0 & 1 & 1 \\ 1 & -1 & 0 \\ -1 & 0 & -1 \end{bmatrix}.$$

   Find the epipolar line in the second image that corresponds to the point $\mathbf{p}$ in the first image. Show that the point $\mathbf{p}'$ lies on that epipolar line. (2p)

   (c) How the epipolar constraint can be utilized in stereo imaging. (1p)

4. Texture

Let us consider the following three grayscale image patches. The first two represent texture classes 1 and 2. The third one belongs to an unknown class.

4	1	4	1
5	1	1	1
3	4	5	3
1	1	2	2

Class 1

1	3	2	1
0	2	2	2
0	5	4	2
4	0	4	3

Class 2

5	2	5	2
2	2	6	2
6	4	4	5
3	3	2	2

Unknown

(a) Classify the unknown sample to either of the classes based on the following approach:

1. Calculate filter responses using the Roberts gradient masks:

0	1
-1	0

1	0
0	-1

   No padding is needed (use only valid pixels).
2. Create feature vectors using the mean values of the filter responses.
3. Use Euclidean distance as a similarity measure to find the closest sample. (3 p)

(b) Describe in detail a procedure based on LBP for solving this texture classification problem. You don't need to calculate the actual result. What problem is related to the given image patches? (3 p)