Machine Vision, exam 21.3.2019

You may write your answers in Finnish or English.

1. Briefly explain the following terms (6 p)

   (a) Metamers

   (b) Unsupervised learning

   (c) Confusion matrix

   (d) Feature descriptor

   (e) Epipolar line

   (f) Multi-view stereo

2. Describe the main principles of the following and give one example of their usage:

   (a) Otsu's method (2 p)

   (b) Convolutional neural network (2 p)

   (c) Local binary patterns (LBP) (2 p)

3. Optical flow

   Given two consecutive frames of imagery:

3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3
3	3	$7_\dagger$	$3_\ddagger$	3	3	3	3	3
3	3	9	7	5	3	3	3	3
3	3	9	9	7	5	3	3	3
3	3	9	9	9	7	5	3	3
3	3	3	3	3	3	3	3	3

Time t_1

3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3
3	3	7	3	3	3	3	3	3
3	3	$9_\dagger$	$7_\ddagger$	5	3	3	3	3
3	3	9	9	7	5	3	3	3
3	3	9	9	9	7	5	3	3
3	3	3	3	3	3	3	3	3
3	3	3	3	3	3	3	3	3

Time t_2

   The intensity function is $f(x, y, t)$. Consider the pixels with spatial coordinates $(3, 4)$ and $(4, 4)$ marked as † and ‡ respectively. (Here we assume that the origin is in the upper left corner so that $f(3, 4, t_1) = 7$ and $f(4, 4, t_1) = 3$.)

   (a) Use the 3×3 Prewitt masks to estimate the spatial derivatives of the image function, $\partial f/\partial x$ and $\partial f/\partial y$, at the points $(3, 4, t_1)$ and $(4, 4, t_1)$. (1 p)

   Note: the Prewitt masks are:

-1	0	1
-1	0	1
-1	0	1

and

-1	-1	-1
0	0	0
1	1	1

   (b) Estimate the temporal derivative $\partial f/\partial t$ at the position $(3, 4)$ and $(4, 4)$. (1 p)

(c) Assume that the image flow vector $\mathbf{v} = (\Delta x, \Delta y)^\top$ is the same for the above neighboring pixels and estimate it by using the image flow equation (2 p)

$$-\frac{\partial f}{\partial t}\Delta t = \nabla f^\top \mathbf{v}.$$

(d) What is the aperture problem? How can it be addressed? (2 p)

4. 2D transformations

(a) Using homogeneous coordinates, write the matrix form of the following transformations: pure translation, pure rotation, similarity (rotation + uniform scaling + translation = RST), affine, and homography. What is the minimum number of 2D point correspondences needed to estimate each? (2p)

(b) A rectangle with corners in $A = (-1, 1)$, $B = (1, 1)$, $C = (1, -1)$ and $D = (-1, -1)$ undergoes a similarity transformation (RST) and the corners are observed at $A' = (1, 0)$, $B' = (1, 4)$, $C' = (5, 4)$ and $D' = (5, 0)$, respectively. Determine the corresponding transformation parameters. (2p)

(c) Let us assume that the points undergo a general affine transformation and they are also subject to random noise. Describe in detail a procedure for estimating the transformation parameters in that case. (2p)