T-61.5070 Computer Vision

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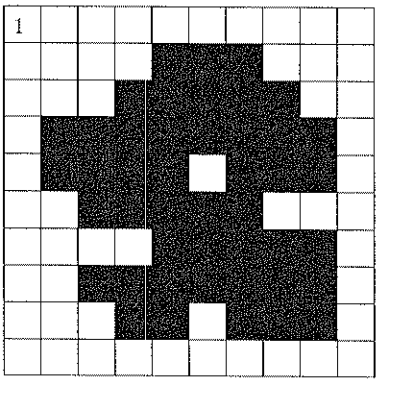
1. Explain briefly, with 20–40 words or a mathematical definition, the following concepts or abbreviations: 6p.

(i) 2.5D sketch
(ii) Moravec detector
(iii) optimal thresholding in segmentation
(iv) texture gradient and its use in computer vision
(v) invariance of features
(vi) shape from X

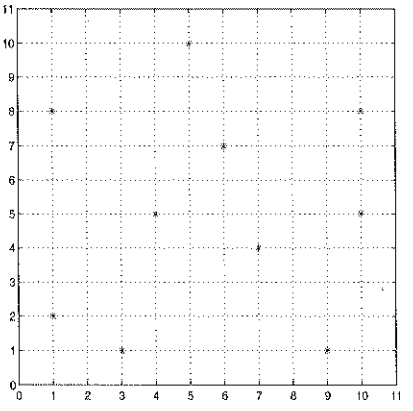
2. (i) Explain the general principles and guidelines in designing and implementing a computer vision system. (ii) Present the block diagram of a computer vision system which is simple but still general enough to serve as an example. Explain the tasks and operation of the entire system and its parts. (iii) Specify what kinds of data structures and control strategies are being employed in your exemplary system and in computer vision system in general. 6p.

3. Below, there is a binary image where it is known to exist one contiguous black object on white background. (i) Explain and visualize how that object's 4-connective inner border can be found. Starting from the top left corner of the image, number all examined pixels by 1,2,3,.... Circle the pixels constituting the inner border. (ii) Explain how the 8-connective outer border can be traced simultaneously when the 4-connective inner border is formed. Draw rectangles around the pixels constituting the outer border. (iii) Explain how the extended boundary can be formed starting from the 8-connective outer border. Draw a separate picture to illustrate the forming of the extended boundary in the case of the image below. (iv) What general problems exist in defining and interpreting different types of borders in binary images? What kinds of solutions do exist? 6p.



Turn page!

4. (i) Explain what Delaunay triangulation means and perform it to the set of data points shown below. (ii) Explain what Voronoi diagram or tessellation means and perform it to the set of data points shown below. (iii) Explain how Delaunay triangulation and Voronoi tessellation are duals to each other and how that is visible in the case of this set of data points. (iv) Explain what the convex hull of a point set means and what is its relation to Delaunay triangulation. Draw it in the same figure with the triangulation. (v) How is the convex hull of an image area in general, what are its parts and how can it be solved? (vi) In what tasks of computer vision the above techniques could be used? 6p.



5. The use of B-spline representation for curve description is studied. (i) Express the general function form with which the course of the B-spline curve $\mathbf{x}(s)$ is determined by control points $\mathbf{v}_i$ and base functions $B_i(s)$. (ii) Let the base functions of a third order B-spline be of the form:

$$
\begin{aligned}
C_0(t) &= \frac{t^3}{6} \\
C_1(t) &= \frac{-3t^3 + 3t^2 + 3t + 1}{6} \\
C_2(t) &= \frac{3t^3 - 6t^2 + 4}{6} \\
C_3(t) &= \frac{-t^3 + 3t^2 - 3t + 1}{6} \quad .
\end{aligned}
$$

Sketch the shapes of the base functions. (iii) Show that the base functions sum up to one and are non-negative when $t \in [0, 1]$. (iv) Show that the base functions are continuous in their start and end points and so are also their first and second derivatives. (v) Let the control points of a third order B-spline be $\mathbf{v}_1 = (1, 1)$, $\mathbf{v}_2 = (3, 2)$, $\mathbf{v}_3 = (4, 4)$ and $\mathbf{v}_4 = (6, 3)$. Calculate the coordinates of the start, middle and end points of the part of the spline curve determined by the given control points. Also, draw a picture and sketch the course of the spline. (vi) Enumerate advantageous characteristics of B-splines for curve description. 6p.