T-61.5070 Computer Vision

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Answers can be given in English, Finnish or Swedish. By filling in the course feedback form http://www.cs.hut.fi/Opinnot/Palaute/kurssipalaute-en.html you can get one extra point in this exam!

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

(i) medial axis transform
(ii) optical flow
(iii) scale space methods in computer vision
(iv) epipolar plane
(v) granulometry in computer vision
(vi) qualitative and quantitative computer vision

2. (i) Explain the general lines of the design and implementation of machine vision systems. (ii) Explain in general and by giving examples how *a priori* information can be utilized in machine vision systems. (iii) Let us assume that your task is to design a machine vision system for aiding a medical doctor in diagnosing angiographic X-ray images of arteries of a human heart. Show the block diagram of the system and explain the used control strategies. Explain the functions of each part and mention some algorithm capable for that purpose. 6p.

3. Image segmentation by using the single-pass split-and-merge algorithm is studied. (i) Draw images of all the 2×2-sized basic patterns for image splitting. (ii) Perform the single-pass segmentation to the image below by using the following rule: the brightnesses of two 4-neighbor pixels belonging to a same region can maximally differ by one. Explain all the steps in the segmentation. (iii) In what cases can the simple rule of the above task lead to a non-unique interpretation? (iv) Could the same segmentation result have been obtained with histogram thresholding? (v) What are the general problems involved in this segmentation method? (vi) What other kinds of segmentation methods do exist? 6p.

1	2	7	7
1	4	5	7
5	3	4	6
5	5	6	6

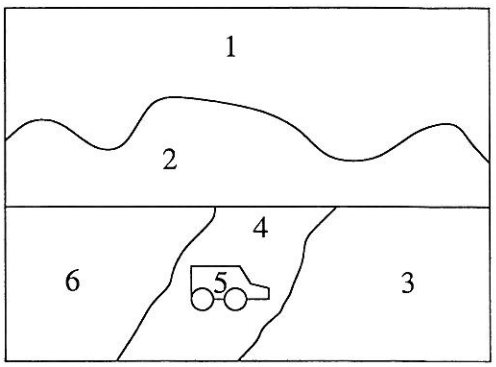
Turn page!

4. 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:

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

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.

5. Below, there is an image segmented to regions 1, 2, ..., 6. We know that region 5 is moving. The image is being labeled with discrete relaxation by using the constraints on the right of the image. (i) Draw the region adjacency graph corresponding to the image. (ii) Show all steps by which the discrete relaxation algorithm finds a mutually consistent labeling of the areas of the image. (iii) What would have followed, if a consistent labeling had not been found? What could have been the reasons for such a situation? What would have been done next? (iv) Explain how constraints f. and g. differ from the other constraints. What would happen if either one were removed? (v) How does probabilistic relaxation differ from discrete relaxation? How could the image interpretation task of this problem be transformed to be probabilistic relaxation? (vi) In what other tasks of computer vision can relaxation be used? 6p.



a. Car (C) is adjacent to road (R).
b. Road is adjacent to grass (G).
c. Grass is adjacent to trees (T).
d. Road is adjacent to trees.
e. Sky (S) is adjacent to trees.
f. Sky is the highest region.
g. Car is moving.