T-61.5100 Digital Image Processing Jorma Laaksonen

EXAM 17.12.2013

Answers can be given in English, Finnish or Swedish.
By filling in the course feedback form
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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) Mach bands and their relation to false contours
(ii) image enhancement and image restoration
(iii) Haar's scaling and wavelet functions
(iv) forms of redundancy in image data and stages of image compression
(v) Hough transform
(vi) hit or miss operator and the use of Golay alphabets

2. (i) Show that a 3×3 -sized averaging mask can be substituted by using 1×3 and 3×1 -sized masks one after another. (ii) Compare the numbers of addition operations needed in the 3×3 case and in the 1×3 followed by 3×1 case. (iii) Accordingly, how do the numbers of addition and multiplication operations compare in the general case when an $n \times n$ -sized mask is separated to $1 \times n$ and $n \times 1$ -sized masks and the mask coefficients differ from unity? (iv) Display the 3×3 -sized Sobel gradient masks. (v) For one Sobel mask, show that its operation can likewise be separated to two one-dimensional mask operations. (vi) Examine, whether a 3×3 -sized discrete Laplace operator can also be realized as two consecutive one-dimensional operations. 6p.

3. 3×3-sized averaging mask operation is compared with median filtering of equal size. (i) Show that the averaging operation is a linear one. (ii) Calculate the power spectrum of the averaging mask and, based on it, show that the mask operates as a low-pass filter. (iii) Explain the principle of median filtering in image processing and explain why it smoothens an image. (iv) Show by using a counterexample that the median operation is not a linear one. (v) By using both filtering algorithms, calculate new values for the pixels shown as bolded in the image below. (vi) Evaluate the result. 6p.

24	24	24	24	3	4
24	**15**	**24**	**22**	**4**	2
24	**24**	**24**	**8**	**2**	3
24	**24**	**24**	**6**	**21**	4
24	**22**	**8**	**4**	**2**	4
24	20	19	8	7	7

Turn page!

4. (i) Explain tristimulus values, trichromatic coefficients and chromaticity diagram. (ii) Sketch the chromaticity diagram by using as its extreme points the following (x, y, λ) values: $(0.75, 0.25, 780\,\text{nm})$, $(0.05, 0.8, 520\,\text{nm})$, $(0, 0.65, 505\,\text{nm})$ and $(0.2, 0, 380\,\text{nm})$. Explain how the hue, saturation and intensity axes are located in the chromaticity diagram. (iii) Place the names of the color spectrum's six colors and white in their correct places in the chromaticity diagram. (iv) Let us suppose that a radiating body produces the unitless tristimulus values $(X, Y, Z) = (33, 51, 136)$. Calculate the trichromatic coefficients (x, y, z), place the calculated (x, y) in the above chromaticity diagram and name the corresponding color. (v) What is the gamuth of a display device and how does it relate to the chromaticity diagram? (vi) Explain why no combination of three radiating bodies can be used to reproduce all the colors of the spectrum. 6p.