T-61.5100 Digital Image Processing

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EXAM 02.09.2008

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

(i) Wiener filtering
(ii) homomorphic filtering
(iii) duality of morphological dilation and opening
(iv) ideal filter and Butterworth filter
(v) approximation and prediction residual pyramids
(vi) discrete gradient operator

2. We will examine the use of the discrete Laplace operator and unsharp masking in image enhancement. (i) Display the 3×3 -sized discrete Laplace operator with value -4 in the middle. (ii) Calculate that spatial filter's frequency response by using the Fourier transform in the case of an $N \times N$ -sized image. Calculate especially the value of the transform for (u, v) frequencies $(0, 0)$, $(0, N/2)$, $(N/2, 0)$ and $(N/2, N/2)$ and explain what kinds of images those frequencies correspond to. (iii) Compare graphically the frequency response of the discrete filter with $-(2\pi)^2(u^2 + v^2)$, the frequency response of the continuous-valued two-variable Laplace operator. What can you state about the phase angle of the operators? (iv) How can the Laplace operator be used in image enhancement? Express the enhancement operation you described also as a single spatial mask operation and in the Fourier domain. (v) Express in the spatial and Fourier domains a 3×3 -sized unsharp masking operation where you use the average value of the pixel and its 4-neighbors. (vi) Calculate the response of the unsharp masking with the same (u, v) values as above and evaluate these two image enhancement methods on the basis of your observations by using the words "highpass filtering" and/or "high-frequency emphasis". 6p.

3. Below there is one row of an image of 8 gray levels and width of 15 pixels. (i) Form a lossless run-length coding for the bit planes of the binary code. It is assumed that each row starts with a 0-valued run and that all run lengths are coded with four bits. (ii) Similarly, form lossless run-length coding based on the bit planes of Gray code. (iii) Calculate the average number of bits needed per pixel for both codings. Also calculate the compression ratios relative to the original representation. (iv) Calculate the relative redundancy of the original representation relative to the better run-length coding. (v) Evaluate the results. How could this coding be further enhanced? (vi) That type of redundancy is here being removed and what other types of redundancy do exist? 6p.

0 0 0 1 1 2 2 5 4 4 7 7 6 6 6

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4. (i) Sketch a picture of the coordinate axes of the RGB color system and explain why the RGB system is used widely. (ii) Mark the coordinate values and corresponding colors in the extreme points of the RGB axis system. Draw the course of the gray-scale axis in the picture. (iii) How is the RGB system converted to the CMY color system? How is the CMY system then converted to the CMYK color system? (iv) Sketch a picture of the coordinate axes of the HSI color system and mark there the gray-scale axis and the same colors with their HSI coordinate values as in the RGB axes picture. (v) Explain what makes the HSI color system better than the RGB system. (vi) Explain, what the different color systems are needed for, for example, those mentioned above. Also tell what is meant by color segmentation and how it is related to different color systems. 6p.