T-61.5100 Digital Image Processing

Jorma Laaksonen

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Remember to fill in the course feedback form
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1. Explain briefly, with 20–40 words or a mathematical definition, the following concepts or abbreviations: 6p.

(i) Mach bands
(ii) discrete Laplace operator
(iii) salt and pepper noise
(iv) linear position-invariant degradation process
(v) morphological hit-or-miss transformation
(vi) chromaticity diagram

2. Different types of distance measures will be studied in two-dimensional discrete space. (i) What conditions must a general function D fulfill in order to be a distance function or metric? (ii) Give the definitions of the Euclidan distance $D_e(p,q)$, the city-block distance $D_4(p,q)$, and the chessboard distance $D_8(p,q)$. (iii) Let two points be $p = (2,5)$ and $q = (8,9)$. Examine and draw which points r of the discrete plane $(x,y) \in [0,15] \times [0,15]$ fulfill the condition $D_e(p,r) = D_e(q,r)$. (iv) Examine similarly points s with the condition $D_4(p,s) = D_4(q,s)$ and points t with the condition $D_8(p,t) = D_8(q,t)$. (v) Analyze your findings. 6p.

3. We will study the use of wavelets in multiresolution processing of a 4×4 -sized image. (i) Haar's scaling function is

$$\varphi(x) = \begin{cases} 1 & , \quad 0 \leq x < 1 \\ 0 & , \quad x < 0 \vee x \geq 1 \end{cases} .$$

Show graphically the set of expansion functions $\varphi_{j,k}(x) = 2^{j/2}\varphi(2^j x - k)$, produced from the above function, that is needed when the length of the processed sequence is four. (ii) Show mathematically how does Haar's wavelet function $\psi(x)$ look like and draw the wavelet set that corresponds to the above expansion functions. (iii) Show how $\varphi_{1,0}(x)$ and $\varphi_{1,1}(x)$ can be formed by using $\varphi_{0,0}(x)$ and $\psi_{0,0}(x)$. What is the more general dependence of which this is an example? (iv) Form from $\varphi_{1,0}(x)$, $\varphi_{1,1}(x)$, $\psi_{1,0}(x)$ and $\psi_{1,1}(x)$ the transform matrix $\mathbf{H}$ that can be used in multiresolution processing of a 4×4 -sized image. (v) By using the above matrix, calculate the transform $\mathbf{T} = \mathbf{H}\mathbf{F}\mathbf{H}^T$, where the analyzed image is

$$\mathbf{F} = \begin{matrix} 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \end{matrix} .$$

(vi) Comment the operations you performed, study the contents of matrix $\mathbf{T}$ in view of multiresolution processing and explain what has been the sense in all this. 6p.

Turn page!