CEG4311 Image Processing
Mid-term exam

Date: Oct. 23, 2006
Time: 14:30-15:50
Professor: E. Dubois
This exam has four pages and two questions. Answer all questions.
Closed-book exam: you may not use any books or notes. Explain all answers; I am more interested in the reasoning than in precise numerical answers. Unless otherwise specified, you may use the results provided on pages 3 and 4 without proof, but state which ones you use. Vous pouvez répondre en anglais ou en français.

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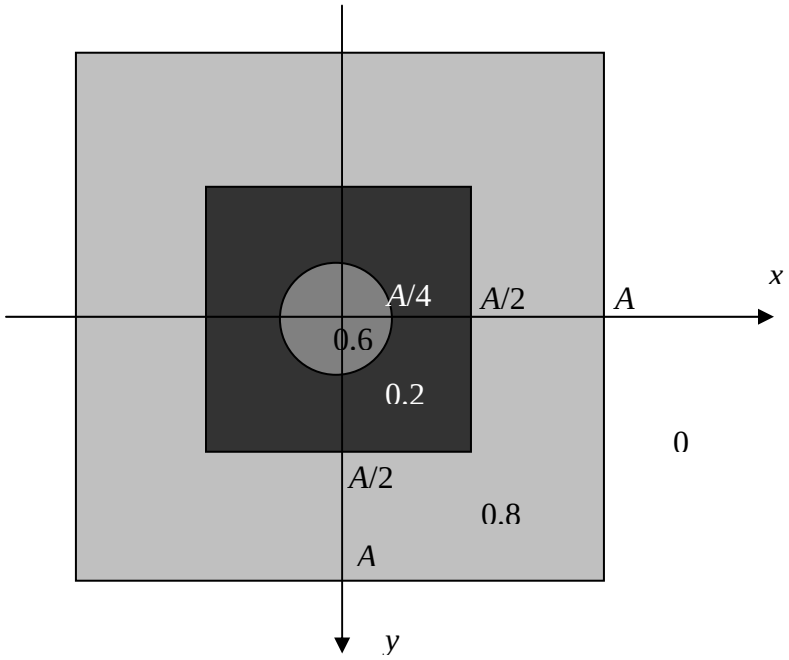
1. (i) Express the following two-dimensional continuous-space function $f(x, y)$ in terms of `rect` and `circ` functions (see page 4 for definitions).
   (ii)Compute the Fourier transform $F(u, v)$ making use of appropriate results from Tables 1 and 2 on page 3.



2. The 8.4Mpixel Panasonic Lumix LX1 digital camera has been advertised as the world's first compact camera with a 16:9 aspect ratio CCD. At maximum resolution, the digital image consists of 3840 pixels horizontally by 2160 pixels vertically, arranged on a rectangular lattice. Given this information, what is the width X and the height Y of each CCD sensor element in units of picture height (ph)? Express your answer numerically as a rational number (fraction) such as 3/64. What is the sampling density (with units) and the number of samples per image?

3. A discrete-space signal $f[x, y]$ is defined on the lattice Λ defined by the sampling matrix

$$\mathbf{V}_{\Lambda} = \begin{bmatrix} 2X & X \\ 0 & X \end{bmatrix}$$

We want to up-sample $f[x, y]$ to the denser lattice Γ defined by the sampling matrix

$$\mathbf{V}_{\Gamma} = \begin{bmatrix} X & 0 \\ 0 & X \end{bmatrix}$$

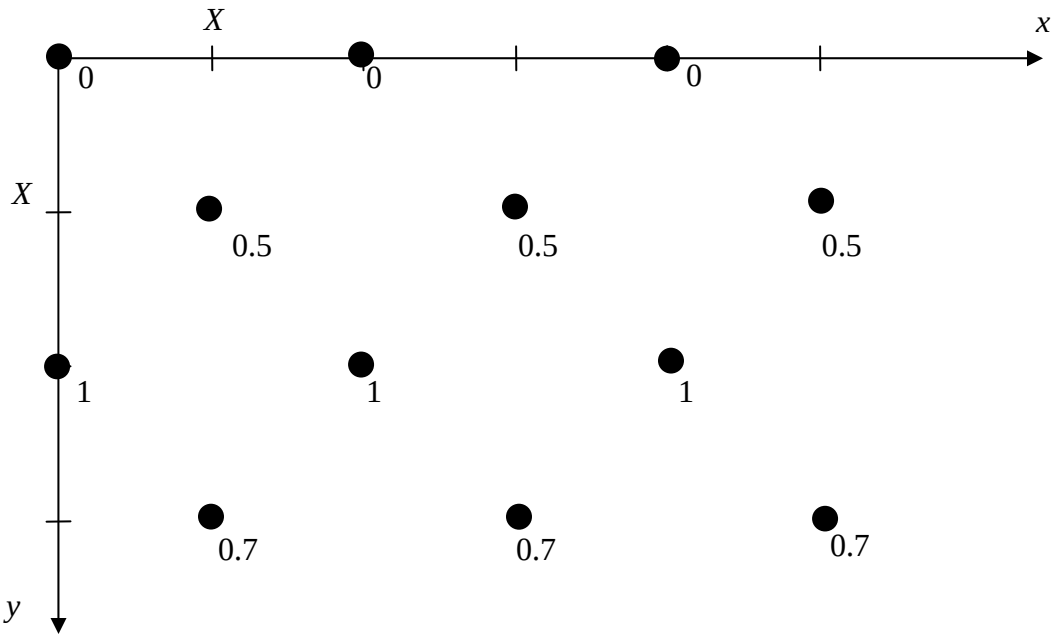
(i) Demonstrate that $\Lambda \subset \Gamma$.

(ii) Draw the block diagram of the system to up-sample $f[x, y]$ to $g[x, y]$, using two blocks or operations. Denote the output of the first block as $q[x, y]$.

(iii) Assume that the filter of the second block has unit sample response

$$h = \begin{matrix} \begin{bmatrix} 0 & \frac{1}{4} & 0 \\ \frac{1}{4} & 1 & \frac{1}{4} \\ 0 & \frac{1}{4} & 0 \end{bmatrix} \begin{matrix} -1 \\ 0 \\ 1 \end{matrix} \\ -1 \quad 0 \quad 1 \end{matrix},$$

and that the top left portion of the input signal $f[x, y]$ is as follows:



Determine and sketch the output of the first block $q[x, y]$ and the output of the second block $g[x, y]$, both defined on the lattice Γ, for $X \le x \le 4X$, $X \le y \le 2X$.

(iv) What is the DC gain of the filter $h[x, y]$? Is this what you would expect?