# CEG4316 Tutorial
# October 11, 2013

**#1** **/20**

(a) (**4 points**) 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. 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?**

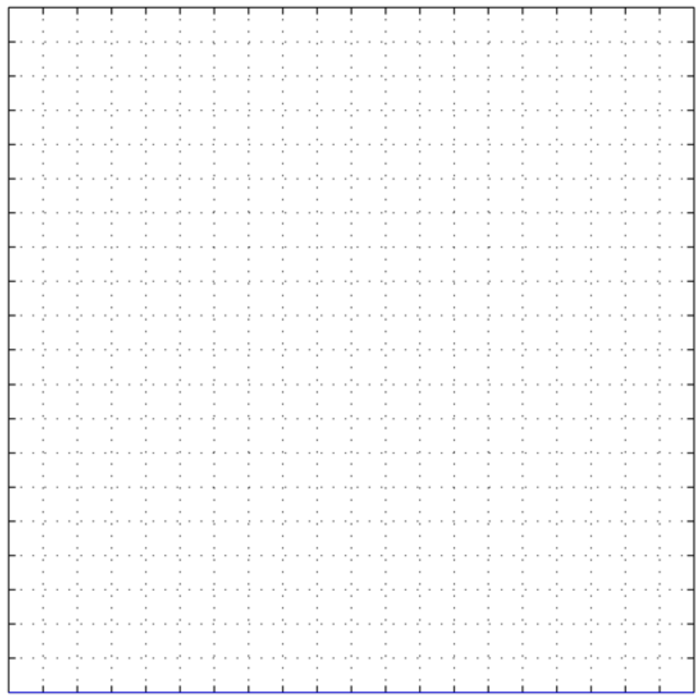
(b) (**4 points**) Assume that the CCD sensor of 2(a) is used with a Bayer color filter array as was used in Lab 2, specifically with the pattern $\begin{matrix} G & R \\ B & G \end{matrix}$. Thus half of the sensor elements are used to capture green samples, while a quarter are used for the red and blue samples respectively. Specifically the green samples are captured on a hexagonal lattice $\Lambda_G$. **Give a sampling matrix $\mathbf{V}_G$ for the lattice $\Lambda_G$. Express it numerically in terms of units of** ph**, again expressing all numbers as fractions.** Assume that the center of the top left green sensor element is the origin of the coordinate system.

(c) (**6 points**) The green channel is upsampled/interpolated by a factor of two to the rectangular lattice of the full CCD sensor. This is accomplished using an FIR filter with unit sample response

$$h_i[x,y] = \delta[x,y] + \frac{1}{4}\delta[x-X,y] + \frac{1}{4}\delta[x+X,y] + \frac{1}{4}\delta[x,y-Y] + \frac{1}{4}\delta[x,y+Y]$$

where $X$ and $Y$ were found 2(a). **Determine the frequency response $H_i(u,v)$ of this interpolation filter and express it in real form. What is the DC gain of the filter?**

(d) (6 points) Assume that the green signal was to be interpolated using an ideal (Voronoi-cell) low-pass filter. **Show the frequency response of this filter on the axes below for $-\frac{1}{X} \le u,v \le \frac{1}{X}$. Clearly indicate the pass-band, stop-band and value of the frequency response on the pass-band. Use cross-hatching to clearly identify the pass-band.** Don't forget that the frequency response is periodic.



#2. A discrete-space signal $f[x,y],\ (x,y)\in\Lambda_1$ defined on a lattice $\Lambda_1$ is to be converted to a signal $g[x,y],\ (x,y)\in\Lambda_2$ defined on a second lattice $\Lambda_2$. The two lattices are specified by their respective sampling matrices $\mathbf{V}_1$ and $\mathbf{V}_2$ as follows:

$$\mathbf{V}_1 = \begin{bmatrix} 3X & X \\ 0 & X \end{bmatrix} \text{ and } \mathbf{V}_2 = \begin{bmatrix} 2X & 0 \\ 0 & 2X \end{bmatrix}$$

(a) State and justify whether $\Lambda_1 \subset \Lambda_2$ or $\Lambda_2 \subset \Lambda_1$ or neither.

(b) Design a system to convert signal $f[x,y]$ into $g[x,y]$ as described above. Show a complete block diagram and give precise definitions of all elements, including all frequency responses. Any LSI filters in cascade should be combined into a single equivalent filter.