EE3206/EE3206E INTRODUCTION TO COMPUTER VISION AND IMAGE PROCESSING

Semester 1, 2013/2014

Tutorial Set A

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1. Consider the three masks M_1, M_2 and M_3 and the image I. (The rest of the image that is not shown is assumed to consist of 0's.)

   (a) Show the results

   $$I_1 = I * M_1, \quad I_2 = I * M_2, \quad I_3 = I * M_3,$$

   where $*$ denotes the masking operation. Describe the effect each mask has on an image.

   (b) Obtain $I_4 = I_1 * M_2$. Write down the mask, M_4 that can be used directly on I to give I_4, i.e. $I_4 = I * M_4$.

$$M_1 = \frac{1}{3}\begin{bmatrix} 1 & 1 & 1 \end{bmatrix} \qquad M_2 = \frac{1}{3}\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} \qquad M_3 = \frac{1}{9}\begin{bmatrix} -1 & -1 & -1 \\ -1 & +9 & -1 \\ -1 & -1 & -1 \end{bmatrix}$$

$$I = \begin{array}{|c|c|c|c|c|c|c|c|c|c|c|}
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline
0 & 0 & 9 & 9 & 9 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline
0 & 0 & 9 & 9 & 9 & 9 & 0 & 0 & 0 & 0 & 0 \\ \hline
0 & 0 & 9 & 9 & 9 & 9 & 9 & 0 & 0 & 0 & 0 \\ \hline
0 & 0 & 9 & 9 & 9 & 9 & 9 & 9 & 0 & 0 & 0 \\ \hline
0 & 0 & 0 & 9 & 9 & 9 & 9 & 9 & 9 & 0 & 0 \\ \hline
0 & 0 & 0 & 0 & 9 & 9 & 9 & 9 & 9 & 0 & 0 \\ \hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ \hline
\end{array}$$

2. Consider the image segment shown below. Let $V = \{0, 1\}$. Using 4-connectivity, determine the connected components that are present. Repeat using 8-connectivity.

$$\begin{array}{cccccc} 1 & 1 & 3 & 1 & 2 & 1 \\ 3 & 2 & 2 & 2 & 0 & 2 \\ 2 & 1 & 1 & 2 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 & 2 \\ 0 & 3 & 1 & 1 & 2 & 2 \end{array}$$

3. Given the 5×5 8-bit images I_1 and I_2 below, obtain
   (a) $A = 0.5(I_1 + I_2)$
   (b) $B = |I_1 - I_2|$
   (c) $C = 0.4I_1 + 0.6I_2$

100	150	200	200	200
100	20	200	200	200
100	20	200	200	200
100	20	200	200	200
100	150	200	200	200

I_1

100	150	200	200	200
100	150	30	200	200
100	150	30	200	200
100	150	30	200	200
100	150	200	200	200

I_2

4. A flat area with centre at $(0, 0)$ is illuminated by a light source with intensity distribution

$$i(x, y) = 512 \exp(-x^2 - y^2)$$

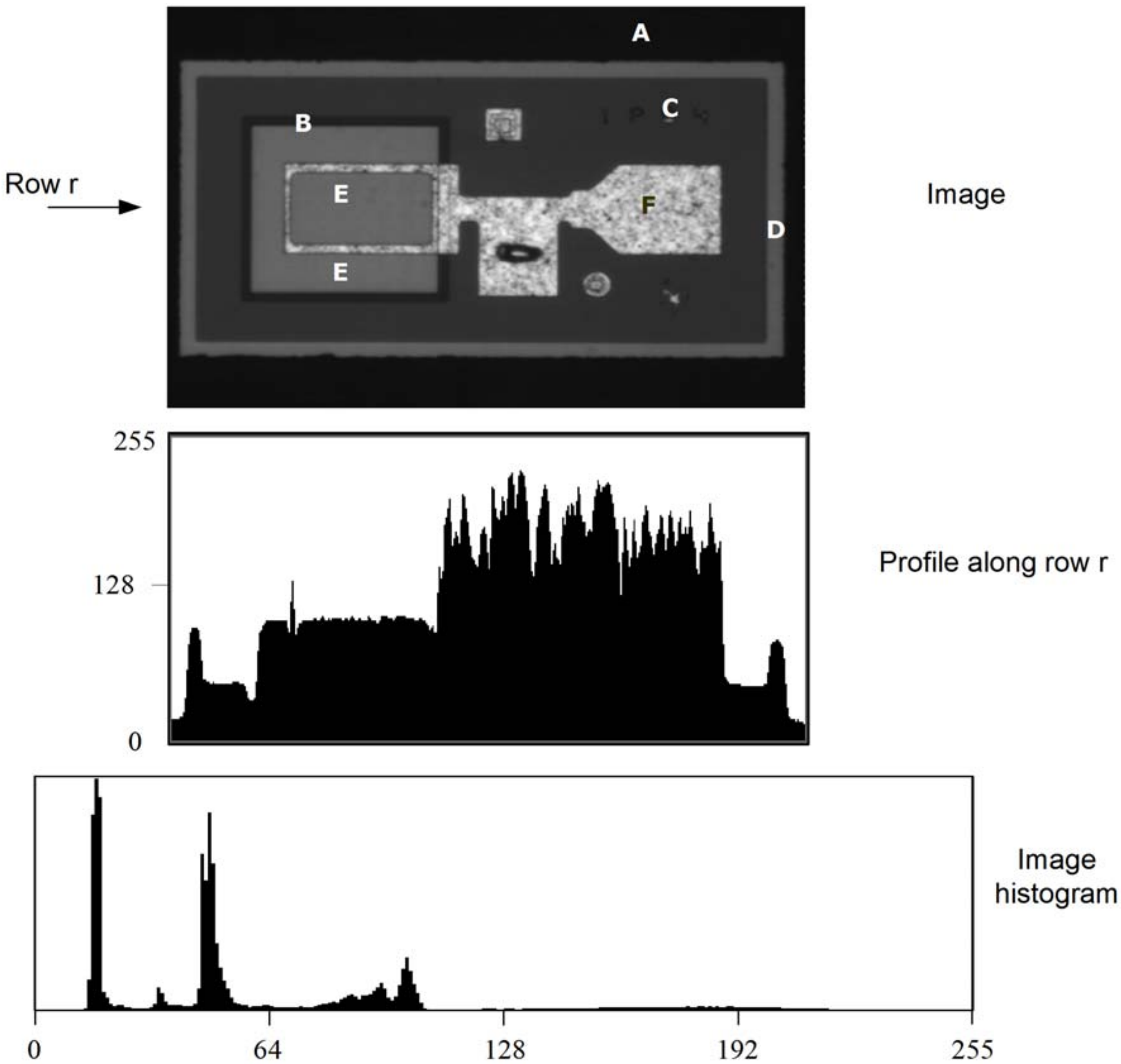
The reflectance of the illuminated area is 1. The image is quantised uniformly into 256 gray levels, which means that the intensity range 0 to ΔG is quantised to gray level 0, ΔG to $2\Delta G$ to gray level 1, and so on.

   (a) Write down the expression for the image function, $f(x, y)$. Sketch the graph that relates the analogue intensity (0 - 512) to the discrete gray levels (0 - 255).
   (b) A 2-bit quantisation scheme is then used to quantise the image. Obtain the equation describing the profile along $y = 0$, ie.e, obtain $f(x, 0)$, and sketch this. Use this to sketch the quantised imagei.

5. The figure shows an image, the intensity profile along the row indicated by the arrow, and its histogram.

   (a) Relate the main modes (or peaks) of the histogram to the regions (A, B, C, D, E) of the image.

   (b) If a constant gray level of 128 is added to all the pixels in the image, sketch the resultant histogram.



6. The histogram of a 16-level 100×100 image can be approximated by

$$h_1(r_k) = A \sin\left(\frac{\pi}{15}k\right) \qquad k = 0, 1, \ldots, 15$$

where A is an appropriate constant. Thus, we have

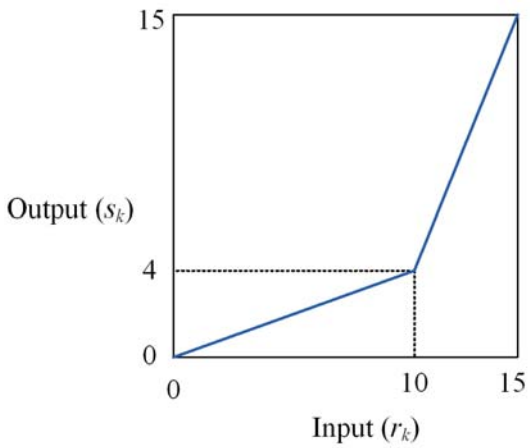
$$h_1(0) = 0, \quad h_1(1) = A\sin(\pi/15), \quad \text{etc.}$$

The transformation function below is applied to h_1, resulting in histogram h_2.

(a) Determine the value of A.

(b) Sketch accurately the histograms h_1 and h_2.

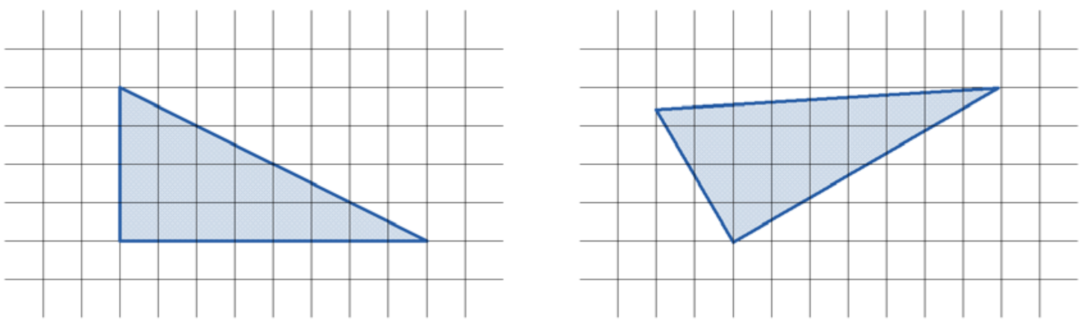
(c) For the two histograms, calculate the mean, m, and the histogram moments μ_2 and μ_3. Comment on the results.



7. This question illustrates image sampling. The figure shows the image of a triangle superimposed on the photoelements of a CCD array.

(a) Estimate the pixel values of the resulting digital image, assuming that a photoelement corresponds to a pixel. (The intensity values of the object and background pixels are, respectively, 80 and 20.) Sketch the result after an intensity threshold of 50 is applied.

(b) The triangle is rotated 30° anti-clockwise to the position shown in the second figure. The image is digitised and as before, thresholded at 50. Sketch the resulting image and compare with the one obtained earlier.



(a) (b)