

1. An image has been quantized to 10 gray levels per pixel and has the following histogram data. Generate the look-up table that will equalize the histogram.

Gray Value	Population
0	11
1	18
2	0
3	1
4	14
5	27
6	5
7	17
8	32
9	19

- (a) Plot the histogram  
 (b) Generate the look-up table that will equalize the histogram.  
 (c) Plot the equalized histogram
2. Consider the  $4 \times 4$  quantized to 3 bits:

1	2	5	6
1	1	4	5
0	1	4	7
3	1	3	4

- (a) Sketch the gray level image histogram.  
 (b) Characterize the histogram (one mode, bimodal, etc.). If bimodal, pick a threshold for binary thresholding transformation.  
 (c) Sketch the histogram of the image after the thresholding transformation.
3. Design the impulse response of a filter that calculates an average along the radial direction specified by  $\phi = +\frac{3\pi}{4}$  and calculates a second derivative along the orthogonal direction. What would this filter be useful for?
4. A rectangular object is to be imaged by a system that adds sinusoidal noise. The image to be recorded is:

$$g[x, y] = \text{RECT} \left[ \frac{x}{16 \text{ mm}}, \frac{y}{32 \text{ mm}} \right] + \cos \left[ 2\pi \left( \frac{x}{4 \text{ mm}} + \frac{y}{6 \text{ mm}} \right) \right]$$

The image is to be sampled with  $\Delta x = \Delta y = 1 \text{ mm}$ .

- (a) Design the transfer function of a filter that will “block” the sinusoidal noise while transmitting as much information about the rectangle as possible.
- (b) What changes do you expect to see in the box image after filtering?
5. Consider the result of a  $7 \times 7$  uniform averaging filter to a digital image  $N$  times (ignore any effects at the edges of the image). Characterize the expected effect.
6. Consider this  $8 \times 8$  three-bit image that contains an edge and some isolated noise points:

0	0	1	2	3	1	1	1
0	0	1	2	3	1	1	1
0	0	1	2	3	1	6	1
0	0	1	2	3	1	1	1
0	0	1	2	7	1	1	1
0	0	1	2	3	1	4	1
0	0	1	2	3	1	1	1
0	0	1	2	3	1	1	1

- (a) Convolve this image with each of the following  $3 \times 3$  convolution kernels.
- (b) Deal with the edges in a manner you think appropriate, but specify what you are doing.
- (c) Comment on the character of the output in each case.

$$1. h_a[n, m] = \begin{array}{|c|c|c|} \hline -1 & -1 & -1 \\ \hline +1 & +2 & -1 \\ \hline +1 & +1 & -1 \\ \hline \end{array}$$

$$2. h_b[n, m] = \begin{array}{|c|c|c|} \hline -1 & -1 & -1 \\ \hline +1 & +2 & -1 \\ \hline +1 & +1 & -1 \\ \hline \end{array}$$

$$3. h_c[n, m] = \frac{1}{9} \begin{array}{|c|c|c|} \hline +1 & +1 & +1 \\ \hline +1 & +1 & +1 \\ \hline +1 & +1 & +1 \\ \hline \end{array}$$

$$4. h_d[n, m] = \begin{array}{|c|c|c|} \hline 0 & 0 & 0 \\ \hline +1 & -1 & 0 \\ \hline 0 & 0 & 0 \\ \hline \end{array}$$

$$5. h_e[n, m] = \begin{array}{|c|c|c|} \hline +1 & +1 & +1 \\ \hline +1 & -8 & +1 \\ \hline +1 & +1 & +1 \\ \hline \end{array}$$

- (d) Apply a  $3 \times 3$  median filter to the digital image. Characterize the output relative to those in (c)