EEC 511/4 Digital Image Processing in VLSI

Assignment

SECTION A

1. The gray scale distribution n_k of an image quantised over 8 levels $r_k; k = 0,1,2,...,7$ is tabulated in (a) and (b) shows the specified histogram with probability density function P_z.

r_k	n_k
0	612
1	163
2	335
3	573
4	1186
5	613
6	614
7	0

(a)

z_k	P_z
0	0
1	0.05
2	0.1
3	0.2
4	0.3
5	0.2
6	0.1
7	0.05

(b)

(a) Perform histogram equalisation on (a) and tabulate the new gray scale distribution quantized into 3-bit.
(b) Perform histogram equalisation using (b) and tabulate the new gray scale distribution quantized into 3-bit.

2. The basic approach used to approximate a discrete derivative involves taking differences of the form

$$f(x,y) - f(x+1,y) + f(x,y) - f(x,y+1)$$

(a) Obtain this filter function in frequency domain.
(b) Without performing detailed mathematical calculation show that (a) is a high pass filter.

Given

$$\Im f(x - x_0, y - y_0) = F(u,v)e^{-j2\pi\left(\frac{ux_0}{M} + \frac{vy_0}{N}\right)}$$

$$2j\sin x = e^{jx} - e^{-jx}$$

$$2\cos x = e^{jx} + e^{-jx}$$

3. A degradation function of a certain image capturing device can be modeled as the convolution of the captured image with the spatial, circularly symmetric function such as

$$h(r) = \left[\left(r^2 - \sigma^2\right)/\sigma^4\right] e^{-r^2/2\sigma^2}$$

where $r^2 = x^2 + y^2$. Show that the degradation in the frequency domain is given by

$$H(u,v) = -\sqrt{2\pi}\sigma\left(u^2 + v^2\right) e^{-2\pi^2\sigma^2\left(u^2+v^2\right)}$$

<u>Given</u>

$$\Im\left[\nabla^2 f(x,y)\right] = -\left(u^2 + v^2\right) F(u,v)$$
$$\Im\left[Ae^{-\left(x^2+y^2\right)}\right] = A\sqrt{2\pi}\sigma e^{-2\pi^2\sigma^2\left(u^2+v^2\right)}$$

4. Write an expression for $\psi_{3,3}$ in terms of the Haar scaling function. Hence draw wavelet $\psi_{3,3}$ for the Haar wavelet function.

(b) Consider the 2×2 image shown in Fig. 4(b).

$$f(x,y) = \begin{bmatrix} 3 & 1 \\ 6 & 2 \end{bmatrix}$$

Fig. 4(b)

(i) draw the require filter bank to implement the two-dimensional FWT with respect to Haar wavelets of Fig. 6(b). Label all inputs and outputs with the proper arrays.

(ii) use the result from 6(b)(i) to draw the require filter bank to implement the two-dimensional inverse FWT. Label all inputs and outputs with the proper arrays.

<u>Given:</u>

The wavelet functions are defined as:

$$\psi_{j,k}(x) = 2^{\frac{j}{2}} \psi\left(2^j x - k\right)$$
$$\psi(x) = \sum_n h_\psi(n)\sqrt{2}\varphi(2x - n)$$

The Haar scaling function is defined as :

$$\varphi(x) = \begin{cases} 1 & ; \quad 0 \le x < 1 \\ 0 & ; \quad \text{elsewhere} \end{cases}$$

The scaling function coefficients for the Haar function are given by:

$$h_{\varphi}(n) = \left\{ \frac{1}{\sqrt{2}}, \frac{1}{\sqrt{2}} \right\} \quad \text{for} \quad n = 0,1$$

The scaling function coefficients for the Haar wavelet are given by:

$$h_{\psi}(n) = \left\{ \frac{1}{\sqrt{2}}, -\frac{1}{\sqrt{2}} \right\} \quad \text{for} \quad n = 0,1$$

SECTION B

5. A computer-based image inspection system was proposed to inspect a 4×3 rectangular block in an image A of size 8×8. However, due imperfection of image capturing devices, noise in the form of small hole and protrusion appear in the block as shown in Fig. 5(b)

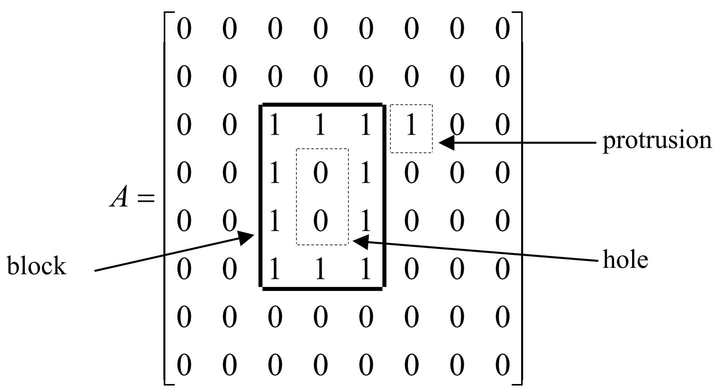

Fig. 5(b)

i. Device a strategy to automatically inspect and locate these types of defects in A. Show clearly the results of the proposed strategy using image in Fig. 5(b). Hence, discuss one main drawback of the proposed strategy.

ii. Implement this strategy in FPGA. Draw the RTL diagram for the corresponding Verilog codes.