University of KwaZulu Natal

School of Electrical, Electronic and Computer Engineering

Examinations: October 2016

Image Processing: ENEL4IPH2

Duration: **2 Hours** Marks: 100

Examiners : Prof. H. Xu (Internal)
: Prof. S. Masupe (External)

Instructions : 1. All Questions should be answered in the answer book.
2. This is not an open book exam and no notes may be used, either electronic or handwritten. Calculator is allowed.
3. JPEG coefficient coding tables are also included in the paper.

Question 1: (10 marks) Mark each of the following statements as T (true) or F (false)

(1) Increasing the cut-off frequency in an ideal 2-D lowpass filter results in more blurring in the filtered image.

(2) The least significant bits in an image plane correspond to edges and sharp transitions in gray values in an image.

(3) The DC component of the following image is 2.

$$\begin{bmatrix} 1 & 2 & 2 & 3 \\ 1 & 2 & 2 & 3 \\ 1 & 2 & 2 & 3 \\ 1 & 2 & 2 & 3 \end{bmatrix}$$

(4) Applying histogram equalization to an image a second time will improve the contrast in the image.

(5) The following mask will highlight horizontal edges in an image.

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$$

(6) Harmonic mean filters ($\hat{f}(x,y) = \dfrac{mn}{\sum_{(s,t)\in S_{ab}} \dfrac{1}{g(s,t)}}$) reduce salt and pepper noise.

(7) A Prewitt operator only uses one mask to process an image.

(8) The following masks are Robert masks.

0	1	2
−1	0	1
−2	−1	0

−2	−1	0
−1	0	1
0	1	2

(9) Shannon-Fano coding is entropy coding.

(10) A linear low-pass filter will always reduce noise and blur the image.

Question 2: (15 marks) Histogram Equalization

(1) (**2 marks**) What is histogram equalization?

(2) (**8 marks**) A 64 x 64 image with seven gray levels (0,1, ..., 6) has a histogram given by:

k	r_k	n_k
0	0	97
1	1/6	296
2	2/6	553
3	3/6	1238
4	4/6	764
5	5/6	426
6	1	722

Determine the transformation for histogram equalization using

$$s_k = T(r_k) = \sum_{j=0}^{k} p_{in}(r_j) \qquad 0 \le k \le 6$$

(3) (**5 marks**) Two operations, image histogram equalization and low pass filter, will be applied in an image. Does the order affect the image processing result or not? Explain your reason.

Question 3: (15 marks) Image Enhancement

(15 marks) In Fig. 1, a 4×4 gray scale original image passes through three spatial linear shift-invariant filters, resulting in three filtered images.

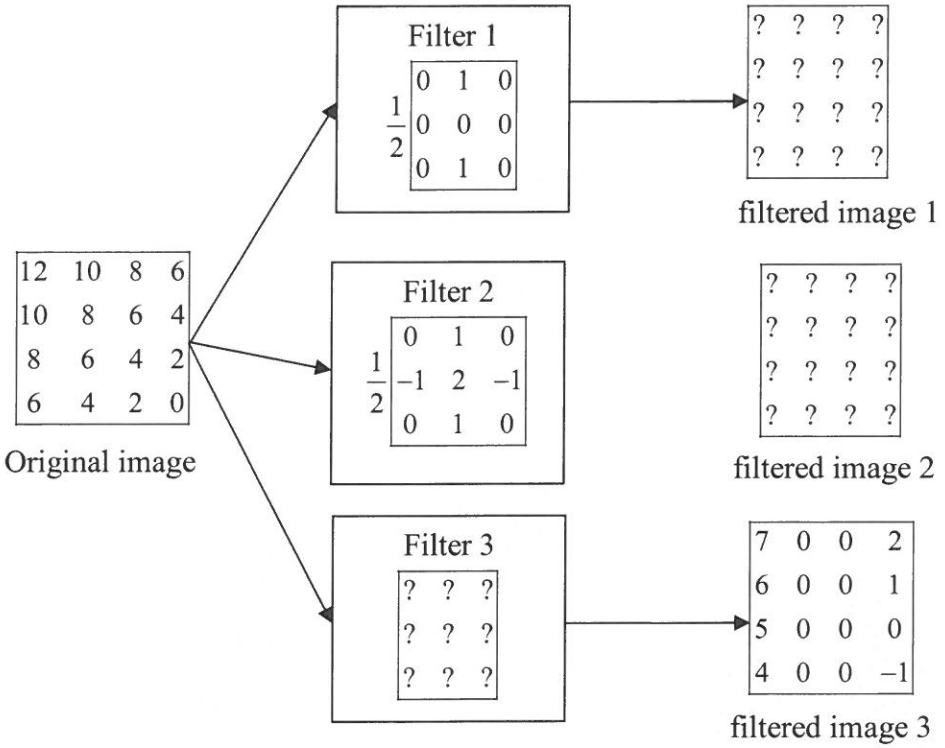


Fig. 1

(1) Compute filtered image 1 using zero-padding.
(2) Compute filtered image 2 using zero-padding.
(3) Based on the relationship between filtered image 1, filtered image 2, and filtered image 3, determine the filter coefficients in filter 3.

Question 4: (15 marks) Image Restoration

Consider a variety of different kinds of images which are degraded by different kinds of point spread function or corrupted by different kinds of noise. Given the following filters: median filter, inverse filter, low pass filter, high pass filter, harmonic mean filter ($\hat{f}(x,y)=\frac{mn}{\sum_{(s,t)\in S_{ab}}\frac{1}{g(s,t)}}$), band reject filter and Wiener filter which one(s) would you use to improve the appearance of images that have been corrupted by the following kinds of processes? Explain your choice.

(1) Image corrupted by salt and pepper noise.
(2) Image corrupted by salt noise.
(3) Image corrupted by low pass filter (convolution with white Gaussian noise).
(4) Image with known power spectrum corrupted by low pass filter (convolution with known white Gaussian noise).
(5) Image corrupted by periodic interference.

Question 5: (16 marks) Image Compression

Part A: (8 marks) JPEG

Fig. 2 is a block of DCT coefficients which have already undergone quantization. Ignoring the DC value, what are the actual symbols that the JPEG Huffman coder will have to encode for this particular block? With the default Huffman tables, how many bits will be needed? (You are not required to write out the actual bit sequence.).

$$\begin{matrix} 16 & -3 & -6 & 0 & 0 & 0 & 0 & 0 \\ 1 & -2 & -1 & 0 & 0 & 0 & 0 & 0 \\ -3 & -2 & -1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix}$$

Fig. 2

Part B: (8 marks) Entropy coding

Given the following table.

Symbol	Probability p_i
S_0	0.3
S_1	0.2
S_2	0.2
S_3	0.2
S_4	0.1

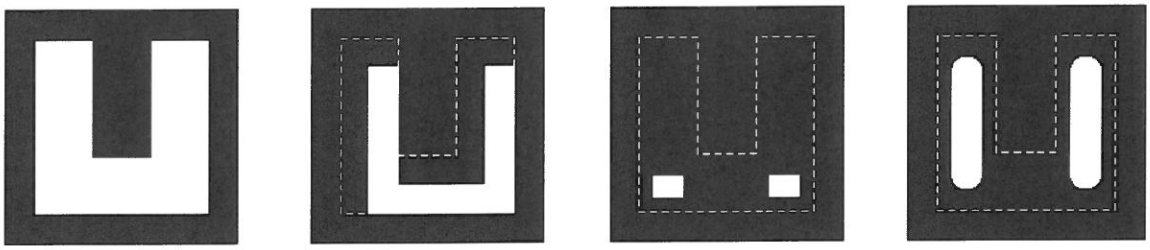
(1) (2 marks) What is the entropy, $H = -\sum_i p_i \log_2 p_i$?

(2) (2 marks) What is the principle for Huffman coding?

(3) (4 marks) Find Huffman code and get its average code length.

Question 6: (15 marks) Binary Morphological Operation

An original binary image is shown Fig. 3. With reference to the image shown, give the structuring element(s) and morphological operation(s) that produced each of the results shown in images (a) through (c). Show the origin of each structuring element clearly. The dashed lines show the boundary of the original set and are included only for reference.



Original (a) (b) (c)

Fig. 3

Question 7: (14 marks) Image Segmentation

(1) (**2 marks**) What is an "edge" in an image?

(2) (**2 marks**) What is "segmentation" in images?

(3) (**10 marks**) The following two masks can be used to detect horizontal lines in an image. Use two examples to determine which mask is used to detect dark lines on a white background and which mask is used to detect light lines on a dark background.

$$\begin{bmatrix} -1 & -1 & -1 \\ 2 & 2 & 2 \\ -1 & -1 & -1 \end{bmatrix} \qquad \begin{bmatrix} 1 & 1 & 1 \\ -2 & -2 & -2 \\ 1 & 1 & 1 \end{bmatrix}$$