University of KwaZulu-Natal

Discipline *of Electrical, Electronic and Computer Engineering*

Image Processing: ENEL4IPH2

Duration: **2 hour** Marks: 100

Examiners : Prof. H. Xu (Internal)
: Prof. Jules Mouatcho Moualeu (External)

Question 1: (10 marks) Concepts

(1.1) (**2 marks**) Given a function $f(x)$, the value of the DFT $F(u)$ at u=0 is also known as the _____ component.

(1.2) (**2 marks**) The bit planes corresponding to most significant bits have the _____ of an image.

(1.3) (**2 marks**) A _____filter is better for removing periodic interference.

(1.4) (**2 marks**) The gray values of an image are from 0 to 255. The image delivers _____ bit information.

(1.5) (**2 mark**) Image compression involves three types of data redundancy: coding, _____ and _____.

Question 2: (15 marks) Image Equalization

An image has the gray level PDF shown in Fig. 2.1 (a). Assume continuous quantities and find the transformation that will transform this image to an image with the PDF shown in Fig. 2.1(b).

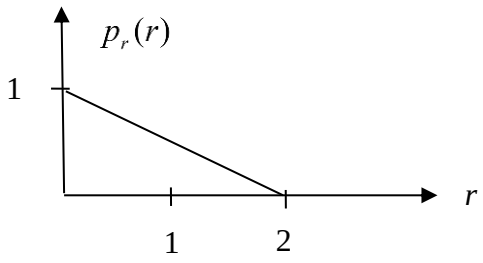


Fig. 2.1(a)

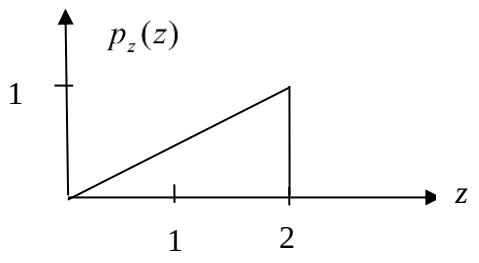


Fig. 2.1(b)

Question 3: (10 marks) Image Enhancement: mask operation

The white bars in the test pattern shown in Fig. 3.1 are 7 pixels wide and 210 pixels high. The separation between bars is 17 pixels. What would this image look like after application of

(3.1) (**5 marks**) a 3×3 min filter;
(3.2) (**5 marks**) a 7×7 min filter.

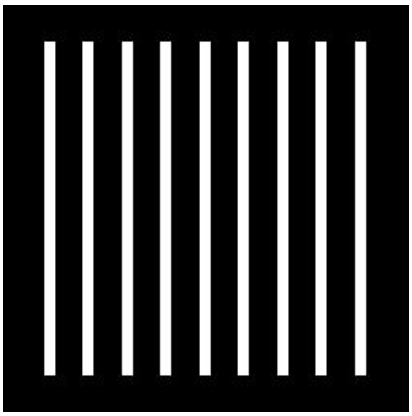


Fig. 3.1

Question 4: (10 marks) Image Enhancement: Transform Operation

(4.1) [**2 marks**] What is the characteristics of the ideal filter?

(4.2) [**8 marks**] Prove the mask $\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$ is a high pass filter in frequency domain.

Question 5: (15 marks) Lossless Image Compression

Consider an information source emitting symbols $\{\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5\}$.

(5.1) (**2 marks**) What is the minimum number of bits required if the probability distribution of the symbols is not available?

(5.2) (**4 marks**) What is the minimum number of bits required if the symbols are distributed as $p(\alpha_1) = 0.1, p(\alpha_2) = 0.1, p(\alpha_3) = 0.2, p(\alpha_4) = 0.3$ and $p(\alpha_5) = 0.3$?

(5.3) (**7 marks**) Construct Huffman code for the symbols with the above distribution.

(5.4) (**2 marks**) Find the average bits for the Huffman code in (5.3).

Question 6: (10 marks) Transform coding

(6.1)(**4 marks**) In the lecture we learnt run length coding, Huffman coding, Shannon-Fano coding and uniform quantizer. Please indicate which coding is lossy coding and which coding is lossless coding in Table 1 below.

Table 1

	Run length coding	Huffman coding	Shannon-Fano	Uniform quantizer
Lossy coding				
Lossless coding				

(6.2)(**6 marks**) In JPEG algorithm after threshold coding the AC coefficients along the zig-zag scan lines are mapped into [run, level], where "level" is the value of non-zero coefficient, and "run" is the number of zero coefficients. Based on the attached Huffman table find the Huffman code for one [run, level]=[2,5].

Question 7: (10 marks) Image Restoration

In the lecture we learnt the contraharmonic mean filter which is given by the expression $\hat{f}(x,y)=\frac{\sum_{(s,t)\in S_{ab}} g(s,t)^{Q+1}}{\sum_{(s,t)\in S_{ab}} g(s,t)^{Q}}$, where the pixel $g(s,t)$ is over the window S_{ab}. Use two examples to explain why the filter reduces pepper noise for positive value of Q and the filter reduces salt noise for negative value of Q, respectively.

Question 8: (10 marks) Image Segmentation

(8.1)(**2 marks**) The mask $\begin{bmatrix} 1 & -2 & 1 \\ -2 & 4 & -2 \\ 1 & -2 & 1 \end{bmatrix}$ can be achieved by two one-dimensional masks. Find the two one-dimensional masks.

(8.2)(**8 marks**) The following two masks can be used to detect horizontal lines in an image. Determine which mask is used to detect dark lines on a white background.

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

Question 9: (**10 marks**) **Binary Morphological Operation**

An original image A and two structuring elements B2 and B3 are shown in Fig. 9.1. Sketch the result of the following morphological operations:

(9.1) (**5 marks**) Erosion of A using B2;

(9.2) (**5 marks**) Erosion of A using B3;

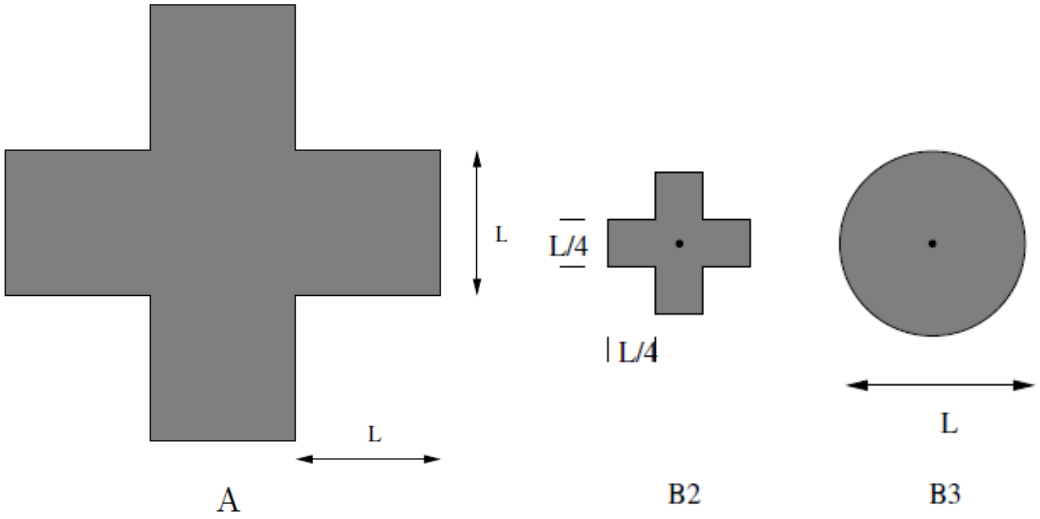


Fig. 9.1