Indian Institute of Space Science and Technology Trivandrum

I SEMESTER , **2023**

ExamType: Quiz 1

DEPARTMENT OF AVIONICS

Digital Image Processing

(Time allowed: ONE hours)

NOTE: Read all questions first. **There are questions worth 30 marks.** If something is missing in a problem description, clearly mention your assumptions with your solution. If require, use sketches to illustrate your findings.

1. Write two different application of image processing? (write short Answer) (1 mark)

2. Putting the corresponding numbers into the boxes below, order the following electromagnetic waves in descending order with respect to their frequencies: (3 marks)

(a) X-rays,
(b) SM signals (cell phones),
(c) Infrared,
(d) Ultraviolet,
(e) Red,
(f) Black,
(g) Blue,
(h) Gamma rays,
(i) Microwave,
(j) FM radio

3. In an 2 bit image (That is, pixels can take values between 0 and 3), number of occurrences of each of pixel values (histogram) are given as:
n0 (Black) = 0,
n1 = 5,
n2 = 80,
n3 = 15

(a) Find histogram equalization transformation function of this image. Show your work. (2 marks)
(b) Apply the transformation function and find the equalized histogram. Plot it. (2 marks)

4. What is a complete and orthonormal set of functions? Give an example. Check if the functions $f_1(x) = x$ and $f_2(x) = x^2$ are orthogonal on the interval $[-2, 2]$. Find constants c_1 and c_2 such that $f3(x) = x + c_1x^2 + c_2x^3$ is orthogonal to both f1 and f2 on the same interval. (5 marks)

5. Compute an SVD of A. Please show all your steps

$$A = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 2 & 0 \\ 0 & 0 & 4 \end{bmatrix}$$

Now, Write A as a linear combination of its elementary images from SVD. Please show all your steps. (5 marks)

6. Let $H_n(t)$ denotes the nth Haar function, where $n \in N \cup \{0\}$.

(a) Give the definition of $H_n(t)$, and derive the Haar transform matrix for 4×4 images according to the definition. (2 marks)

(b) Using the Haar transform matrix derived above to compute the Haar transform A_{Haar} of A. where

$$A = \begin{bmatrix} 5 & 3 & 9 & 0 \\ 3 & 9 & 0 & 5 \\ 9 & 0 & 5 & 3 \\ 0 & 5 & 3 & 9 \end{bmatrix}$$

(2 marks)

(c) By setting the four smallest (in absolute value) nonzero elements of A_{Haar} to 0, we obtain A_{Haar}. Compute the reconstructed image $\hat{A}$ of $\hat{A}_{Haar}$. (2 marks)

7. Convolving with a box kernel in the spatial domain is equivalent to: (1 mark)

(a) Multiplication with a sinc in frequency domain

(b) Convolution with a box in frequency domain

(c) Multiplication with a gaussian in frequency domain

(d) Convolution with a sinc in frequency domain

8. Let $f(x, y)$ denote an image and $f_G(x, y)$ denote the image obtained by applying the Gaussian filter $g(x, y)$ to $f(x, y)$. In the image processing literature an operation called high boost filtering generates an image $f_B(x, y) = af(x, y)f_G(x, y)$, where $a \geq 1$.

(a) You are asked to use one filter to achieve the high boost filtering. The filter you should use is: (1 mark)

(i) $\delta(x, y) - g(x, y)$
(ii) $1 - g(x, y)$
(iii) $a\delta(x, y) - g(x, y)$
(iv) $a - g(x, y)$

(b) If G(k,l) is the frequency domain response of g(x,y), the frequency response of this filter is given by: (1 mark)

(i) $\delta(k, l) - G(k, l)$
(ii) $a - G(k, l)$

(iii) $a\delta(k,l) - G(k,l)$
(iv) $1 - G(k,l)$

(c) The shape of this filter in the frequency domain is similar to a: (1 mark)

(i) Low-pass filter
(ii) High-pass filter
(iii) Band-pass filter

9. Consider the following gray and white checkerboard image:

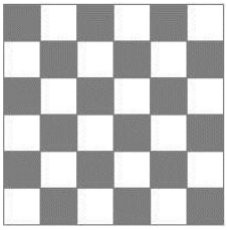

Figure 1: checker board

(a) Which of the following is the histogram of this image? (1 mark)

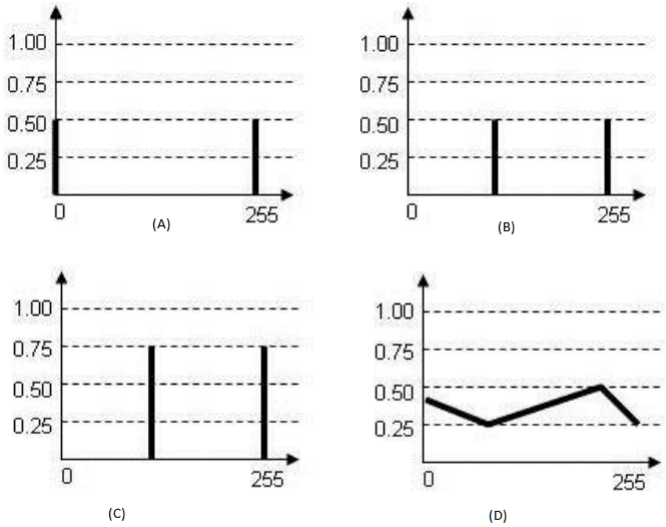

Figure 2: choose the histogram

(b) What is the expected histogram after global histogram stretching has been applied to this image? (1 mark)

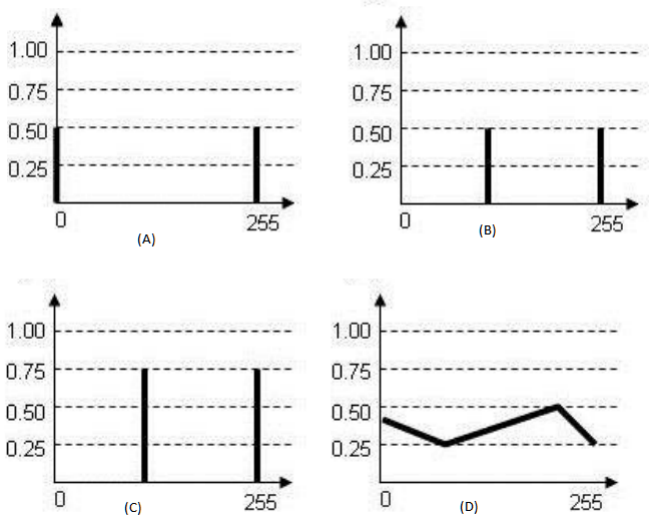

Figure 3: choose the histogram after global histogram stretching