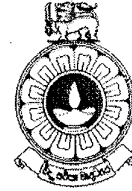


The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mechanical Engineering



Study Programme	: Bachelor of Science Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	: DMX5314/DMX5571 Machine Vision
Academic Year	: 2022/2023
Date	: 30 th January 2024
Time	: 09.30-12.30
Duration	: 3 hours

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Five (5)** questions in **Five (5)** pages.
3. Answer for each question should commence from a new page.
4. This is a Closed Book Test (CBT).
5. Answers should be in clear handwriting.
6. Answer to all questions.

Question 01

- a) Illustrate the use of human vision and machine vision in different real-world scenarios.
[05 marks]
- b) A colour model is an abstract mathematical model that describes how colours can be represented as a set of numbers. Select any two colour models and describe them briefly.
[05 marks]
- c) Discuss the illumination types used in machine vision systems.
[05 marks]
- d) Briefly explain the architecture of a machine vision system in a manufacturing environment.
[05 marks]

Question 02

a) Describe the following:

- i) Reason for low contrast images.
- ii) Importance of histograms in image processing.

[04 marks]

b) Provide a concise analysis of the two histograms associated with the given images shown in Figure 1.

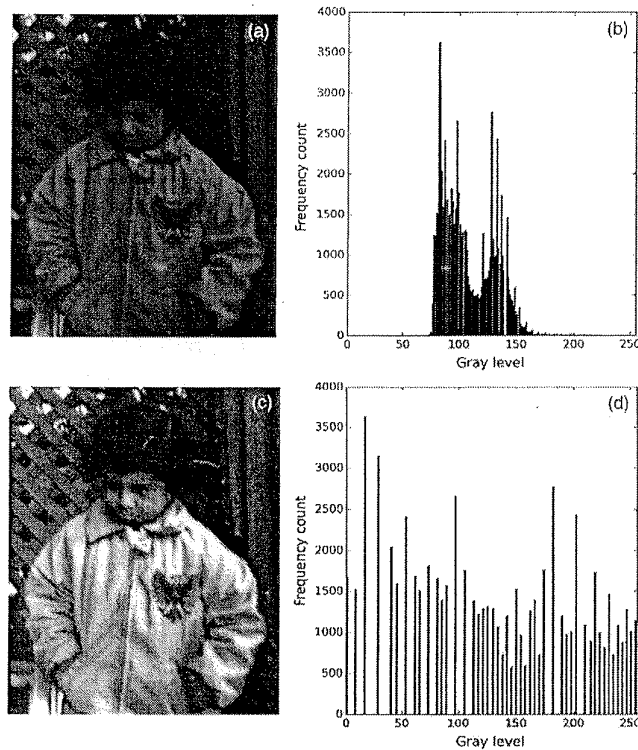


Figure 1

[04 marks]

c) Explain why the discrete histogram equalization technique does not, in general, yield a flat histogram.

[02 marks]

d) Perform histogram equalization on the given 3-bit 4x4 image matrix.

$$M = \begin{bmatrix} 0 & 0 & 0 & 4 \\ 1 & 1 & 1 & 5 \\ 1 & 2 & 2 & 7 \\ 2 & 2 & 2 & 7 \end{bmatrix}$$

[10 marks]

Question 03

- a) Explain the Nearest Neighbor interpolation and binary threshold interval operator mathematically.

[02 marks]

- b) Perform the Nearest Neighbor interpolation to enlarge the given 3 by 3 image to a 5 by 5 image matrix.

$$f = \begin{bmatrix} 0 & 2 & 4 \\ 2 & 4 & 6 \\ 4 & 6 & 8 \end{bmatrix}$$

[05 marks]

- c) Calculate the output image using the binary threshold interval operator, assuming grey levels of the image matrix shown in Figure 2.

$$q = \begin{cases} 0 & \text{for } p_1 \leq p \leq p_2 \\ 1 & \text{for } p < p_1 \\ & p > p_2 \end{cases}$$

$$\begin{aligned} \text{Let } p_1 &= 3 \\ p_2 &= 12 \end{aligned}$$

06	07	08	01	00	03	03	03
10	11	03	14	02	05	06	07
03	03	12	00	15	03	03	03
15	02	00	01	01	13	14	00
15	00	01	02	02	15	01	00
12	12	12	02	15	10	11	03
04	07	05	15	14	10	04	05
09	08	04	13	13	12	12	12

Figure 2

[05 marks]

- d) You have been assigned to develop a robot-vision system to automatically pick up postal parcels. The parcels, all of the same size (40 x 30 x 15 cm) are placed on a conveyor belt moving at 20cm/s. The camera used in tracking the parcels has a frame rate of 30 frames/second. In addition, for a successful pick-up action, the robot controller requires that a parcel should be located with a precision of at least 3mm. Briefly explain whether the robot can grasp the parcel or not, and what are the solutions can you propose to modify the system?

[08 marks]

Question 04

- a) Sketch a block diagram model for the image degradation/restoration process and give the equation describing the model in both the spatial and frequency domains. [02 marks]

- b) Describe how the first and second-order derivatives can be used to detect edges, how they are different from each other, how they are affected by noise, and which filter masks can be used. [02 marks]

- c) Explain how to apply image processing techniques to calculate the center and area of a brain tumour from scanned binary images. (Hint: the moment equation)

$$M_{i,j} = \sum_{x=1}^m \sum_{y=1}^n x^i y^j I(x,y)$$

[02 marks]

- d) Explain the terms erosion and dilation regarding image processing, Figure 3 represents an image and the structuring element. Perform the dilation and erosion operations on the image.

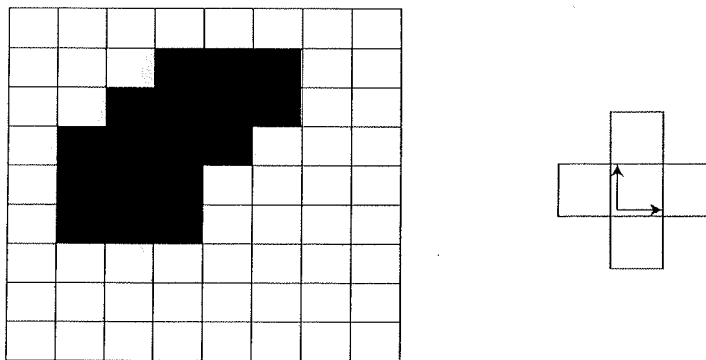


Figure 3

[06 marks]

- e) Discuss how image addition, subtraction, and multiplication are applied, illustrating a real-world scenario. [03 marks]
- f) Explain the concept of motion detection in Unmanned Aerial Vehicles (UAVs) using classical image processing algorithms. Discuss the fundamental principles behind motion detection and how it is applied in the context of UAVs. Describe the key components and steps involved in the motion detection process using classical image processing techniques. [05 marks]

Question 05

- a) Explain the significance of camera calibration in the context of machine vision applications. [2 marks]
- b) Evaluate the pros and cons of Convolutional Neural Networks (CNN) and classical image processing techniques, exploring how each approach influences the effectiveness of machine vision systems. [4 marks]
- c) A computer vision-based fire detection and extinguishing mobile robot system features an overhead-mounted camera to capture real-time images from a high-risk indoor area. The system is designed to detect fire flames in the desired area and extinguish them using the mobile robot. The vision system is responsible for detecting emergency fire flames and obtaining real-world coordinates from the images to transmit location data to the mobile robot. Design the computer vision system by clearly indicating the assumptions, design steps, machine vision techniques, sketches, and flowchart algorithm. [08 marks]
- d) Figure 4 shows the frame arrangement of the mobile robot, camera, and the fire object. Now the robot will be navigated for a fire extinguishing process with this vision system. Explain how the robot should be moved from its home position to a fire object considering the homogeneous transformation matrices.

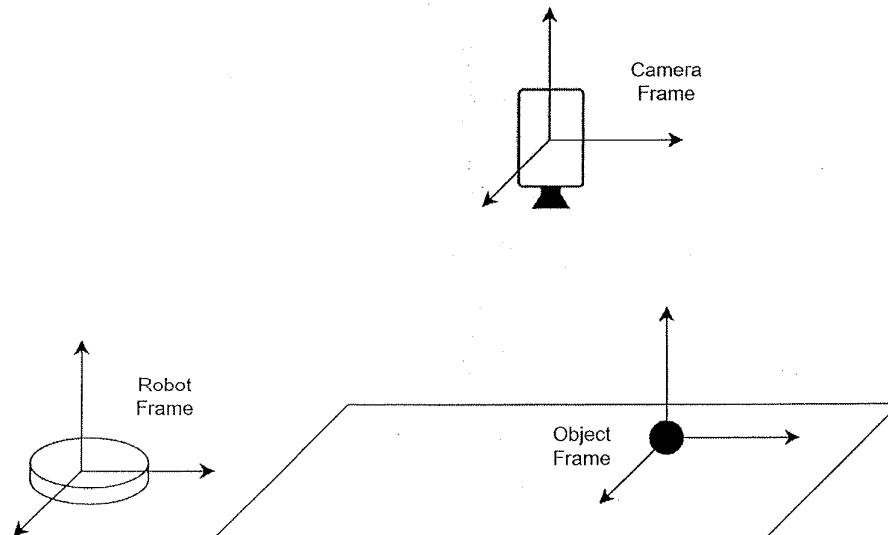


Figure 4

[06 marks]

END