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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 – Machine Vision**
Academic Year	:	2023/2024
Date	:	20th of March 2025
Time	:	1330 – 1630 hrs
Duration	:	**3 hours**

General Instructions

1. Read all instructions carefully before answering the questions
2. This question paper consists of **Five (5) compulsory** questions in four (4) pages.
3. All questions carry equal marks.
4. Answer to each question should commence from a new page.
5. This is a Closed Book Test (**CBT**).
6. The symbols used in this paper have their usual meanings.
7. Clearly state any assumptions that you may make.
8. Answers should be in clear handwriting. Do not use a red pen.
10. You are not allowed to use a programmable calculator.

Question 01

1. Briefly discuss spatial correlation and convolution. [4 marks]
2. With the use of a suitable diagram, explain the process of image formation in a human eye. [4 marks]
3. With the use of an example discuss the reasons for using image additions and image subtractions in image processing. [4 Marks]
4. Name the most suitable lighting system to be used for the below scenarios. Give justifications. [4 marks]
    a. To get surface texture of features of an object in stationary.
    b. To examine bone fractures with X-ray plates.

5. Discuss 'spectrum response' and 'speed of response' considering a human vision system and a machine vision system. Provide numerical values as applicable to justify your answer. [4 marks]

Question 02

1. Consider the following data given for a vision system to answer questions from **a** to **c**. The size of the 100 × 100 sensor array is 0.4 cm × 0.4 cm, and the size of the object to measure is 8 cm ×8 cm. [6 marks]

    a. Magnification
    b. Pixel size
    c. Depth of the field when the f-stop value is 16

2. A courier company has hired you to build a robot-vision system to automatically pick up parcels from a conveyor belt. The parcels carry exercise books placed inside them. The parcel size is 60 cm x 30 cm x 10 cm. The conveyor belt moves at a speed of 15cm/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 2mm.

    a. Briefly explain whether the robot can grasp the parcel or not. Show all the calculations. [8 marks]

    b. What are the solutions you can propose to modify the system? Elaborate giving reasons and suitable calculations. [6 marks]

Question 03

1. Briefly explain dyadic two-point transformations using a suitable drawing. [4 marks]

2. Discuss **why** it is needed to use 'contrast stretching' with respect to image processing? [4 marks]

3. Consider the given input image matrixes with **16 gray levels.** [12 marks]

$$\text{Input image matrix} - \begin{bmatrix} 15 & 11 & 8 & 9 & 0 & 0 \\ 14 & 10 & 4 & 13 & 1 & 0 \\ 13 & 10 & 3 & 3 & 2 & 4 \\ 12 & 9 & 2 & 2 & 4 & 5 \\ 14 & 10 & 1 & 1 & 6 & 6 \\ 15 & 15 & 14 & 10 & 10 & 11 \end{bmatrix}$$

Find the relevant output image matrix in each case, when the following operators are used.

a. Inverse operator

b. Threshold operator when $q = \begin{cases} 0, & p < p_1 \\ 1, & p \geq p_1 \end{cases}$. Let $p_1 = 9$

c. Inverted grey scale threshold interval operator when

$$q = \begin{cases} 15 - p, & p_1 \le p \le p_2 \\ 0, & p < p_1 \text{ and } p > p_2 \end{cases}$$

Let p_1=3 and p_2= 13

d. Inverted binary threshold interval operator when $q = \begin{cases} 0, & p_1 \ge p \ge p_2 \\ 1, & p_1 < p < p_2 \end{cases}$

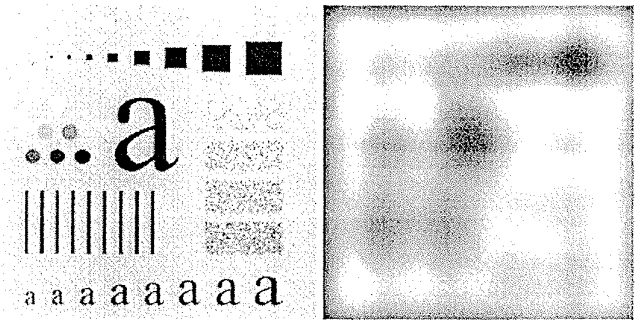
Let p_1=2 and p_2= 12

Question 04

1. Using a suitable diagram or any other means, briefly describe the steps involved in filtering in the frequency domain. [3 marks]

2. Consider the two images given in Figure Q4. (a) (Original image) and Figure Q4. (b) (Severely blurred image). Suggest a suitable filter to be used to remove the blurry effect. Justify your answer. Discuss the effect of increasing the filter radius.

[4 marks]



(a) (b)

Figure Q4

3. Consider the below 3-bit image (8 intensity levels) of size 4 × 4 pixels. Perform **histogram equalization** for the given image and obtain the equalized histogram. Make sure you include the following in your answer: - the original image histogram, a table with all calculations, output image in matrix format and the equalized histogram.

[13 marks]

$$\begin{bmatrix} 5 & 1 & 3 & 2 \\ 3 & 3 & 4 & 7 \\ 1 & 2 & 3 & 4 \\ 3 & 2 & 3 & 3 \end{bmatrix}$$

4 × 4 image

Gray scale = [0,7] = 8 intensity levels

Question 05

Imagine that you are hired as a vision-based system expert at the *CoolMilk* dairy product manufacturing company from last month. You are assigned to **develop a vision-based non-contactable system** for identifying the straw that should be attached with a fresh milk packet as shown in Figure Q5. [20 marks]

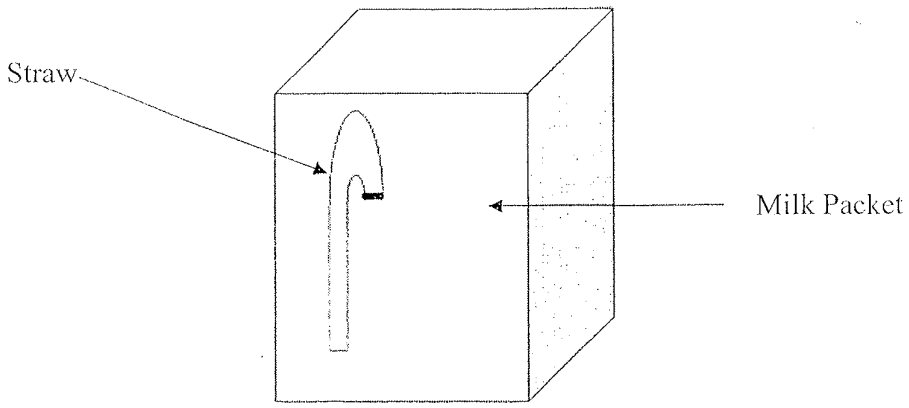


Figure Q5

Please note that this milk pack must be checked when it is on the conveyor belt and is not allowed to remove it from the conveyor belt during the inspection. If the straw is not attached to the milk packet, then it should be handled using an automated system as well.

Stating clearly the assumptions, write an **algorithm** (Use a flow chart) for this straw detection system. You need to address the **three main functions** of a machine vision system that are Image acquisition, Processing and Display. Describe how you are going to place the necessary components on the manufacturing cell. Briefly describe the sensors and actuators which you may use for this system.

Draw a complete machine vision system for the above task, labelling all components used. (Hint: You need to assume the components that should be included considering the above scenario).

Now, consider the function of Image Processing of the system you selected.

Briefly describe the **Image enhancement methods** and **Feature extraction methods** that you can apply to this system.

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