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

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: DMX5571/MEX5271 Machine Vision**
Academic Year	: 2017/18
Date	: 31st January 2019
Time	: 0930-1230hrs
Duration	: **3 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Six (6)** pages.
3. Answer any **Five (5)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. This is a Closed Book Test (CBT).
6. Answers should be in clear hand writing.
7. Do not use Red colour pen.

Question 01

An automobile manufacturer is automating the placement of certain components on the bumpers of a limited-edition line of sports cars. The components are colour coordinated, so the robots need to know the colour of each car in order to select the appropriate bumper component. Models come in only four colours: blue, green, red, and white. You are hired to propose a solution based on imaging. How would you solve the problem of automatically determining the colour of each car, keeping in mind that cost is the most important consideration in your choice of components? [*12 marks*]

a) One of the several HDTV formats is 1080p24, which means video stream of full frames of 1920×1080 pixels at frame rate 24 fps. If each pixel has 24 bits of intensity resolution (8 bits each for red, green and blue channels). Find the gigabytes are needed for 2 hours of HDTV video without compression. [*4 marks*]

b) Discuss *human vision* Vs. *machine vision* considering decision making, speed of response and quality of measurement. [*4 marks*]

Question 02

a) Image subtraction is used often in industrial applications for detecting missing components in product assembly. The approach is to store a "golden" image that corresponds to a correct assembly; this image is then subtracted from incoming images of the same product. Ideally, the differences would be zero if the new products are assembled correctly. Difference images for products with missing components would be nonzero in the area where they differ from the golden image. Describe the conditions that do you think have to be met in practice for this method to work. [*12 marks*]

b) Explain why the discrete histogram equalization technique does not, in general, yield a flat histogram. [*8 marks*]

Question 03

a) Given the 3-bit 4×4 image is shown in Figure Q3.1. Perform the histogram equalization and find the resulting image. [10 *marks*]

$$M = \begin{array}{|c|c|c|c|} \hline 0 & 0 & 0 & 4 \\ \hline 1 & 1 & 1 & 5 \\ \hline 1 & 2 & 2 & 7 \\ \hline 2 & 2 & 2 & 7 \\ \hline \end{array}$$

Figure Q3.1

$$f = \begin{array}{|c|c|c|} \hline 0 & 2 & 4 \\ \hline 2 & 4 & 6 \\ \hline 4 & 6 & 8 \\ \hline \end{array}$$

Figure Q3.2

b) Given an 3×3 image is shown in Figure Q3.2. You want to enlarge the image to an 5×5 image. Explain nearest neighbor and bilinear interpolation and show how the resulting 5×5 image will look for each of the two interpolation methods. [*10 marks*]

Question 04

Cameras are often modeled as Pinhole Cameras as shown in Figure Q4, which project points of light in the real world onto the image plane. Suppose we have a point in an image, denoted (x, y), that corresponds to a point in the real world, denoted (X, Y, Z). After a little geometry, we get the following relations:

$$x = f\frac{X}{Y} \qquad y = f\frac{Y}{Z}$$

Consider f is the focal point of the camera. As you can see, if we are just given a point in an image, solving for the point in the real world is underdetermined. Assume that you have two cameras that are taking pictures of the same object. Suppose the change in perspective of camera 1 to camera 2 is given by a rotation R and translation T.

a) How you can map point $X_1 = (x_1, y_1)$ in the image from camera 1 to the image from camera 2? [*15 marks*]

b) How you can recover the real world coordinates (X, Y, Z). [*5 marks*]

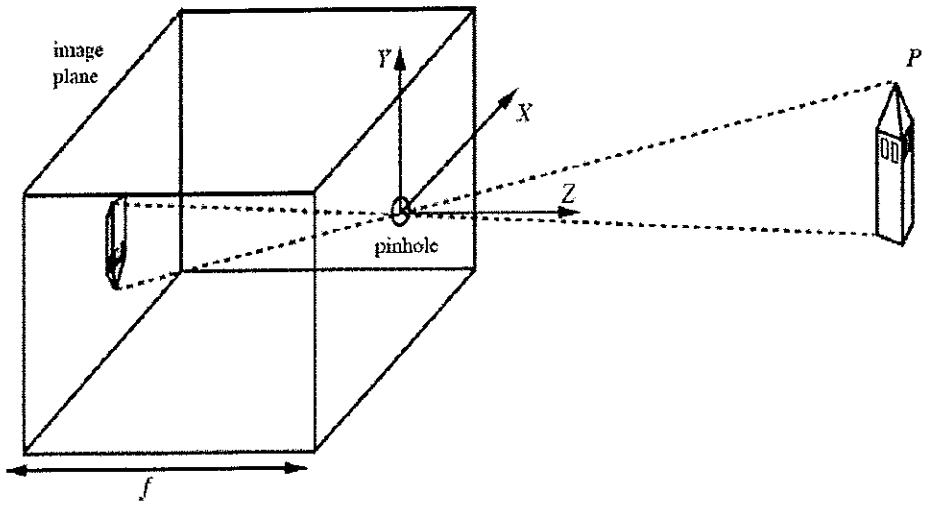

Figure Q4

Question 05

A professor of archeology doing research on currency exchange practices during the Roman Empire recently became aware that four Roman coins crucial to his research are listed in the holdings of the British Museum in London. Unfortunately, he was told after arriving there that the coins recently had been stolen. Further research on his part revealed that the museum keeps photographs of every item for which it is responsible. Unfortunately, the photos of the coins in question are blurred to the point where the date and other small markings are not readable. The cause of the blurring was the camera being out of focus when the pictures were taken. As an image processing expert and friend of the professor, you are asked as a favour to determine whether computer processing can be utilized to restore the images to the point where the professor can read the markings. You are told that the original camera used to take the photos is still available, as are other representative coins of the same era. Propose a step-by step solution to this problem. [*20 marks*]

Question 06

Three features (lake, bay, and line segment) useful for differentiating thinned objects in an image are shown in Figure Q6. Develop a morphological/logical algorithm for differentiating among these shapes. The input to your algorithm would be one of these three shapes. The output must be the identity of the input. You may assume that the features are 1 pixel thick and that each is fully connected. However, they can appear in any orientation. [*20 marks*]

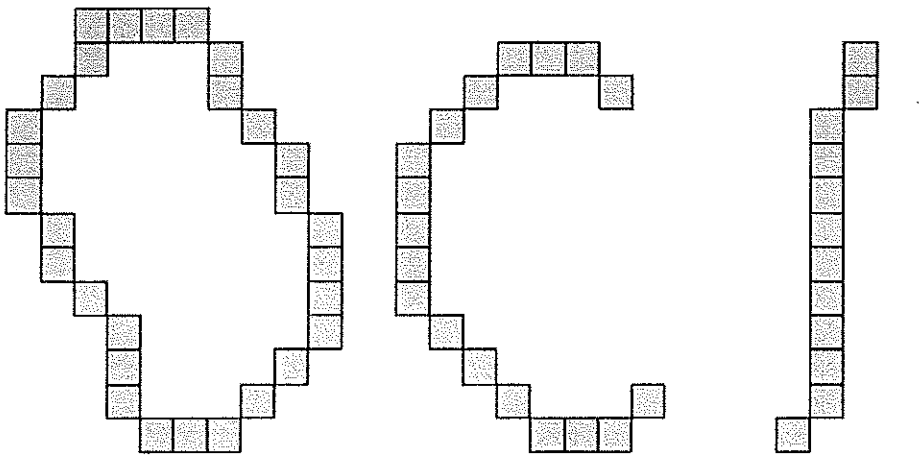

Figure Q6

Question 07

a) Consider an automated vision-based system for dimensional measurement. The system setup has an object view of a $4cm$ by $4cm$ square. The solid state sensor is a 512 by 512 array arranged in a $0.8cm$ by $0.8cm$ square. If the required tolerance of the measurement is $20\mu m$, determine whether this system setup is suitable. Explain briefly. [*10 marks*]

b) Consider a surface inspection system using a microscope. The vision system has a 256 by 256 sensor array, arranged in a $0.8cm$ by $0.8cm$ square, the lens has a f − stop of 16 and a magnification of 10. Determine whether the system can be used to inspect surface irregularities with a maximum height of $0.05mm$. Explain briefly. [*10 marks*]

Question 08

Consider the 5×7 image shown in Figure Q8 below, with grey levels from 0 to 15. This image is composed of a bright 5×4 part on the left and a dark 5×3 part on the right.

a) Plot the histogram of this image and that of its inverse. [*4 marks*]

b) Design a point processing to transform the left part of the image to white and right part to black, and show the resulting image (round the number to the closest integer). [*3 marks*]

c) After step (b) above, the left part of the image is not completely white due to the presence of noise. Use a 3×3 average mask to filter this noise. [*3 marks*]

d) Threshold the image resulting from step (c) above to make the left part completely white and the right part completely black. Show the resulting image. [*3 marks*]

e) Process the image resulting from step (b) above using a 3×3 median filter. Compare your result with the result from (c). Is step (d) also needed in this case? [*3 marks*]

f) Design a 3×3 mask and describe how you can use it to detect the "vertical edge" separating the left and right parts of the image resulting from step (e). What mask would you use to detect horizontal edge? [*4 marks*]

13	10	09	08	01	01	00
15	14	13	15	02	02	02
14	01	12	14	00	03	00
13	15	11	12	01	02	01
14	15	Of'	13	01	00	04

Figure Q8

END