00036

THE OPEN UNIVERSITY OF SRI LANKA
FACULTY OF ENGINEERING TECHNOLOGY - LEVEL 5
FINAL EXAMINATION – 2011/2012
MEX5271 – MACHINE VISION

DATE : 01st March 2012
TIME : 0930HRS. – 1230 HRS.
DURATION : THREE HOURS (3)

READ THE FOLLOWING INSTRUCTIONS CAREFULLY BEFORE ANSWERING THE QUESTION PAPER.

The question paper has **eight** questions.

Answer **five** questions only.

Q1.

a) Using suitable diagrams proof the duality relation between erosion and dilation which is $(A \oplus B)^c = A^c \ominus B$

b) Discuss what illumination is and its four categories.

c) Compare and Contrast Tube type cameras and Solid state cameras.

d) Explain what Edge detection is and how Gradient operation is used in edge detection.

e) Discuss Spatial filtering and its applications.

Q2.

a) Find the 4x4 matrices which achieve the following:

i. a translation by (3,5,2)

ii. a rotation about the X axis by 45 degrees

b) Figure Q2 shows a point ***P,*** which has the coordinates of (1, 1, 0), when refers to its own coordinate frame (x^1,y^1,z^1). The coordinate frame (x^1, y^1, z^1) has been translated from the origin of the coordinate frame (x, y, z) by an amount of (3, 3,0), and has been rotated about the z-axis by a positive 45°. Find the coordinates of point P refereeing to the base coordinate frame which is (x, y, z). You need to clearly explain all steps in finding the answer.

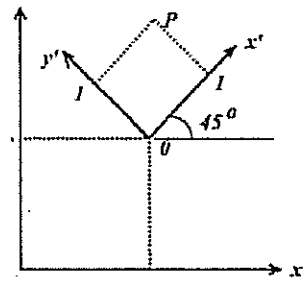


Figure Q2

Q3. Consider the 4×5 image shown in Figure Q3 below, with gray levels from 0 to 15. This image is composed of a bright 4×2 part on the left and a dark 4×3 part on the right.

a) Plot the histogram of this image.

b) Plot the histogram of inverse of the original image.

c) Design a point processing to transform the left part of the original image to white and the right part to black, and show the resulting image.

d) Get the binary output image matrix if the threshold value is 04.

After step	15	05	03	00
13	01	05	01	01
14	12	03	01	00
12	10	09	03	02

Figure Q3

Q4.

a) Consider an automated vision-based system for the sorting of two products on a production plant. The current system setup provides an image capturing window measuring 4 cm by 4 cm square. The CCD camera has a solid state sensor array of 0.8 cm by 0.8 cm square, which has a resolution of 1024 by 1024 pixels. Lens size is 25mm. If the required tolerance of the measurement is 40 μm, determine whether this system setup is suitable if the object distance should be between 125mm to 140mm. Discuss about the design briefly.

b) Design with the aid of structured lighting, a computer vision based system to measure the heights of the two protrusions of the machine component shown in Figure Q4.

$d_1 > d_2$

$t_1 > t_2$

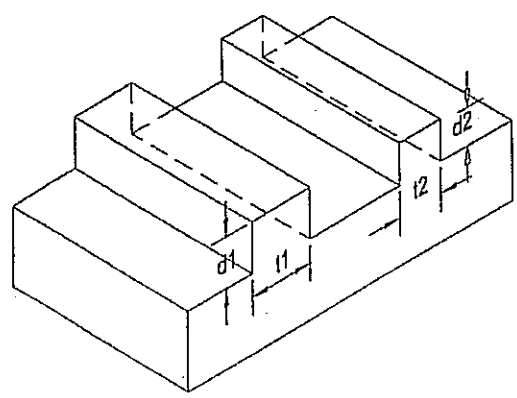


Figure Q4

Q5.

a) For the following image A and structuring element B, determine

i. erosion $A \oplus B$

ii. closing $A \bullet B$

$$A = \begin{matrix} 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{matrix} \qquad B = \begin{matrix} 0 & 1 & 0 \\ 1 & 1 & 1 \\ 0 & 1 & 0 \end{matrix}$$

b) Figure Q5(i) and Figure Q5(j) shows a digital image (I) and a structured element (J), respectively. Determine the digital image after the following morphological operations:

i. $(I \oplus J) - I$

ii. $(I \oplus J) - (I \ominus J)$
[Note : Submit your results in the sheet provided with the question paper]

iii. Describe the functions of each of these operations

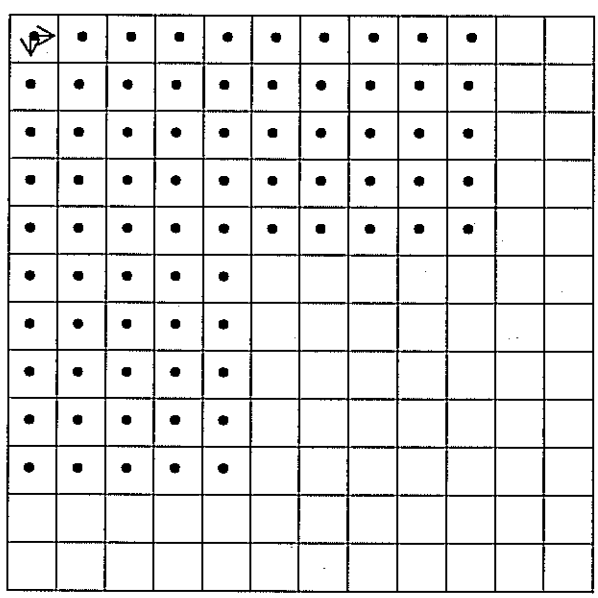


Figure Q5(i)

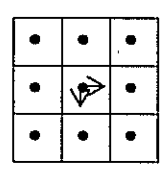


Figure Q5(j)

Q6.

a) Consider the following camera model assuming that the camera and world coordinate systems are aligned. The camera is translated by an amount of (0, 2, 2), and it is rotated by an angle 90 degrees around the Z axis, followed by a rotation of 45 degrees around the X axis. Both rotations are in clockwise directions. After that the image plane is displaced by an amount of (0.02, 0.01, 0.03) with respect to the camera center. Finally, perspective projection is applied to form the image. Focal length of the camera is 0.030.

Find the image coordinates of the world point (1, 1, 0.2).

b) Structured light is employed to determine the 3D geometry of postal parcels. A parcel in the form of a triangular solid with a rectangular base is shown in Figure Q6. Describe how you can find the angle Beta(β) of this parcel. You can assume that in this setup, the light source can be at different angles.

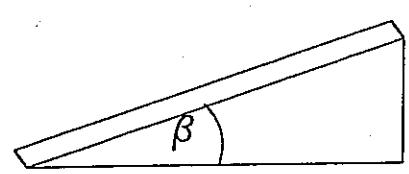


Figure Q6

Q7.

a) An image has the gray level probability density function $P_r(r)$ shown I Figure 7(a). We wish to transform gray levels of the image so that they will have the specified $P_z(z)$ shown in Figure 7(b). Assume continuous quantities; find the transformation (in terms of r and z) that will accomplish this.

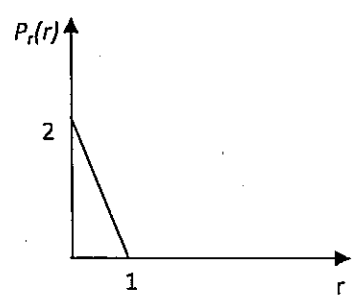


Figure 7 (a)

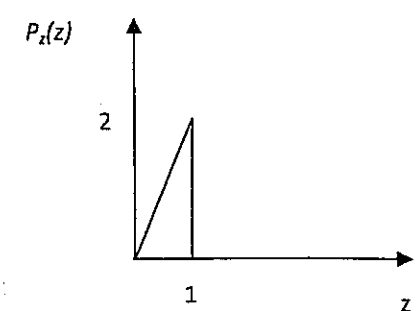


Figure 7 (b)

b) An engineer is asked to inspect a certain class of images generated by a machine vision system. He has decided to use digital image enhancement and has examined a set of representative images. He has found the following problemS :

i. Bright and isolated dots are of no interest.

ii. Lack of sharpness

iii. Insufficient contrast in some images

iv. Shift in the average gray level value from

He wishes to correct these problems and then colour in constant red all gray levels between a given band between I_1 and I_2, while keeping normal tonality in the remaining gray levels. Propose a sequence of processing steps that the engineer can follow to achieve the desired goal.

Q8.

(a) For a spatially discretised *M x N* image, denoted by *f*(i,j), the p^{th} , q^{th} moment is given by:

$$m_{pq} = \sum_{i=0}^{M} \sum_{j=0}^{N} i^p \, j^q \, f(i, j)$$

Figure Q8(a) and Figure Q8 (b) show images of a rectangle in 2 orientations formed by arrays of gray or white pixels. For each orientation, determine the moment m_{00}, m_{10} and m_{01} and comment on your results. Use an intensity of 1 for gray pixels and 0 for white pixels. The '+' in the diagrams indicates the origin.

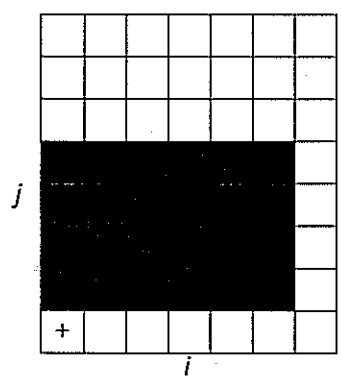


Figure 8(a)

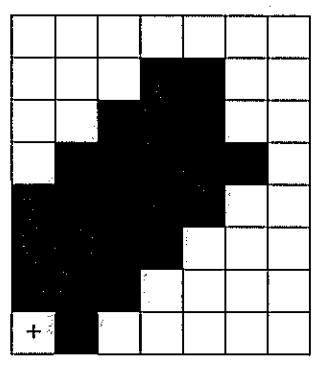


Figure 8 (b)

(b) The central moments of the images shown in Figure 8(a) and Figure 8(b) are given below:

	μ_{20}	μ_{02}	μ_{11}
Figure 8(a)	70	30	0
Figure 8 (b)	45.91	59.3	30.13

An invariant moment ϕ_1 is defined as $\phi_1 = \eta_{20} + \eta_{02}$ and

$$\eta_{pq} = \frac{\mu_{pq}}{\mu_{00}^{\gamma}}, \gamma = 0.5 * (p+q) + 1$$

Calculate the invariant parameter ϕ_1 for each image shown in Figure 8(a) and Figure 8 (b), and give your comments on the results.

(c) Calculate the areas and perimeters of the two images shown in Figure 8(a) and Figure 8(b), and hence determine the ratio Area/(Perimeter)^2 in each case. Comment on your results.

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