The Open University of Sri Lanka
Faculty of Engineering Technology

Study Programme	:	Bachelor of Technology Honours in Engineering
Name of the Examination	:	Final Examination
Course Code and Title	:	**MEX 5271Machine Vision**
Academic Year	:	2014/2015
Date	:	27th August 2015
Time	:	09.30am – 12.30pm
Duration	:	3 hours

General instructions

1. Read the question carefully before answering the questions.
2. This question paper consists of 8 questions. All questions carry equal marks.
3. Answer any 5 questions only.

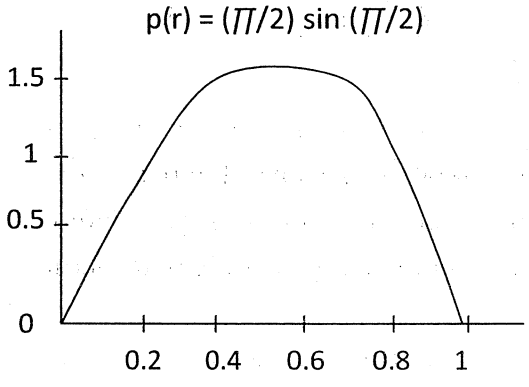
Q1 Consider an image with gray levels from 0 (black) to 15 (White).

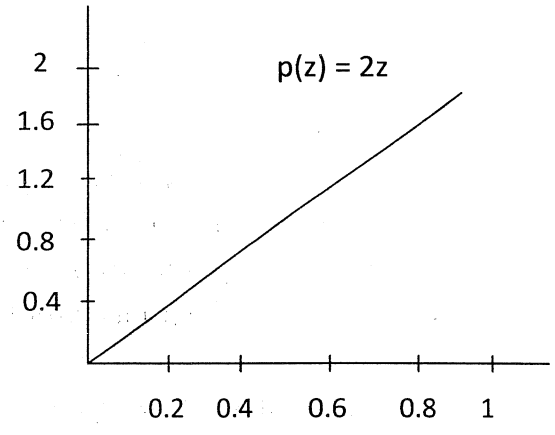
1	2	0	3	1	1
3	12	9	15	13	2
0	13	7	13	11	3
1	8	10	7	11	1
2	9	12	14	10	2
2	0	1	3	1	4

(a) Establish the histogram of this image. Design a point processing transform to convert the 1-pixel frame (gray level < 6) to black and leave the inner 4 x 4 window (gray level ≥ 6) unchanged. Give the histogram of the transformed image and of the negative of this transformed image.

(b) Let us now consider the inner 4 x 4 window. Define a linear point processing transform to stretch the gray levels to cover the whole available range.

(c) Consider the two histograms below, defined as continuous functions on the interval [0, 1]. Specify the two gray level transformations bringing these two histograms into each other, i.e. find the functions $z = z(r)$ and $r = r(z)$.





Q2. A micro-robot is controlled based on visual information captured from an optical microscope. This microscope is equipped with a lens of 9mm focal length, and has a rectangular 8.8 x 6.6 mm CCD sensor array with 768 x 493 pixels. The frame rate is 30 frames/seconds and the magnification is 50.

a) What is the size (in microns) of one pixel on the object plane ? At which distance of the image are the objects sharp? Can an object with width 10 microns be seen completely sharp if a f – stop of 16 is used? (explain). If the object is not sharp, how can the system be modified to make it entirely sharp? (explain).

b) An Object has a 10 microns long straight edge. The error on this edge can be computed as

i) at least one pixel, or
ii) corresponds to significantly less than 1 pixel ? (explain).

What is your answer when the edge is only 1 micron?

c) There are time-dependent fluctuations in the image, i.e. the image can be modeled as P(I,j) + noise (I,j), when the noise is uncorrelated for each (I,j) and has zero mean. We decide to filter this noise by averaging consecutive images. How much time would be required to achieve to reduce the standard deviation of the noise by a factor 10 ? Give your calculations.

Q3. 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 conveyer 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.

(a) Can the robot grasp the parcels successfully? (explain). If the answer is no, what solutions can your propose to modify the installation, and what is the best solution?

(b) Which kind of camera and lighting would you use to make the system as simple as possible? Justify your answer. If some parcels have different dimensions, what kind of lighting would you use? (explain).

Q4. a) What is image compression?

b) Describe Huffman encoding and Huffman decoding.

c) Explain two types of JPEG image compression.

d) Describe about inter-pixel redundancy and psycho-visual redundancy.

Q5 (a) 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 Fig. Q5.

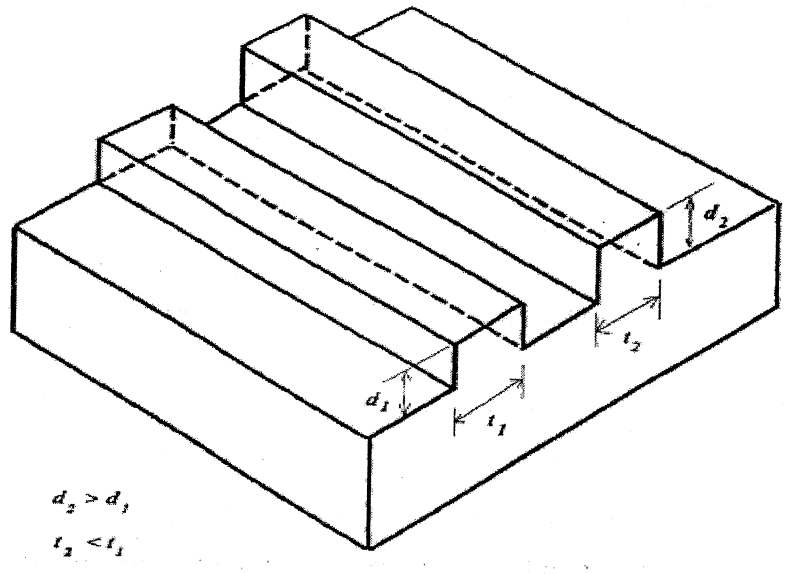


Fig. Q5

(b) Consider an automated machine vision based system for the sorting of the gender of juvenile guppy. The objective is to detect the presence and the size of a small black dot at a certain part of the body. The current set up of the system provides an image capturing window measuring 2cm by 2cm square. The CCD camera has a solid state sensor array 0.8 by 0.8 cm square, which can have a resolution of 512 by 512, 1024 by 1024, or 2048 by 2048 pixels. For the lenses, you are only allowed to use the available sizes, which are 25 mm, 35mm or 50mm. If the required tolerance of the measurement is 20 μm, and the object distance should be between 100 to 125mm, design the system by choosing the appropriate lens and sensor array resolution. You are to note that the camera (with any of the stated array size) costs much more than the lenses. In addition, the higher the resolution of the sensor array, the more expensive is the camera. Discuss briefly your design.

Q6. (a) A, B and X are sets in 2-dimensional integer space Z^2, and $A = B \oplus C$ for some C in Z^2, show that

$$X \circ A \subseteq X \circ B$$

and

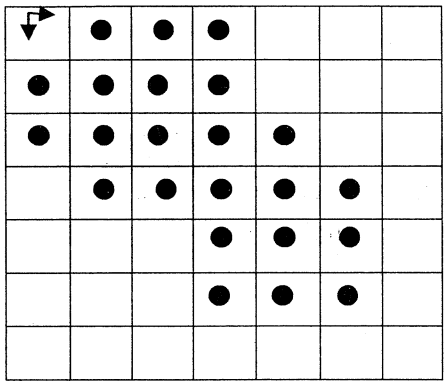
$$(X \circ A) \circ B = (X \circ B) \circ A = X \circ A$$

(c) Fig. Q6 shows a digital binary image **A**, and two structural elements **B** and **C**. Determine the results of the following morphological operations :

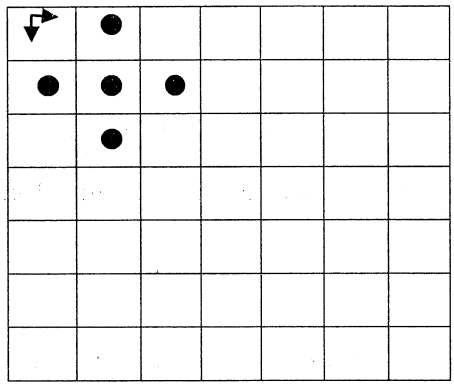
iii. A o B

iv. A o C

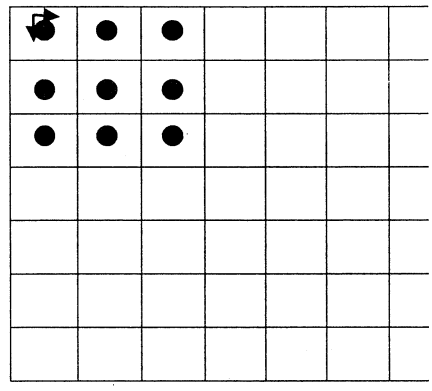
What conclusion can you draw from the resulting images after the above operations.



A



B



C

Fig. Q6

Q7. (a) Sketch the polar signature of the object shown in Fig. Q7.

(b) Discuss how you could determine the orientation of an object with its polar signature.

(c) Discuss the problems that one may encounter when using the polar signature approach in object recognition.

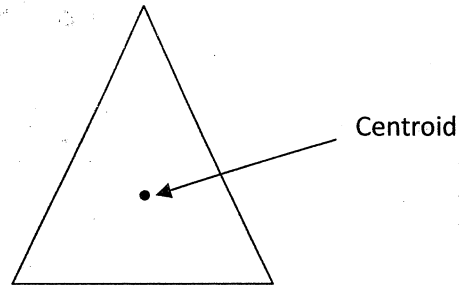


Fig. Q7

Q8. (a) For a spatially discretised M x N image, denoted by f (I,j) the p^{th} , q^{th} moment is given by

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

Fig. Q8 shows images of a rectangle in 3 orientations formed by 5 x 5 arrays of gray or white pixels. For each orientation, determine the moment m_{00}, m_{10} & 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.

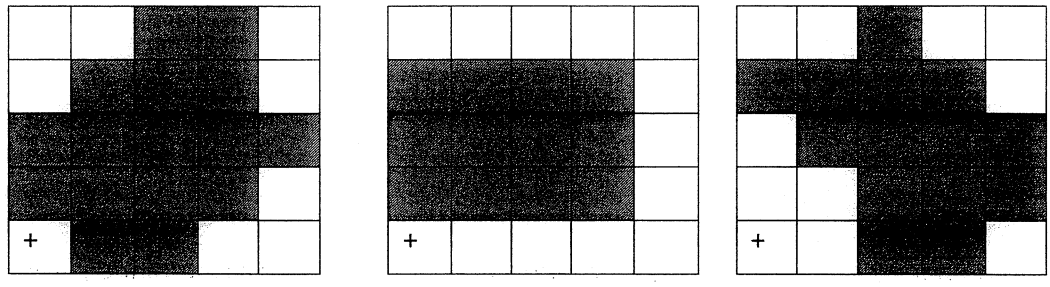


Fig. Q8

(b) The central moment is defined as

$$\mu_{pq} = \sum_{i=0}^{M} \sum_{j=0}^{N} (i-i_c)^p (j-j_c)^q f(i,j)$$

Where i_c and j_c are the coordinates of the centroid of a given image region. Explain the physical significance of μ_{20} and μ_{02} . If the central moment translation invariant?

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

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

$\mu_{20} = m_{20} - i_c m_{10}$

$\mu_{02} = m_{02} - j_c m_{01}$

Calculate the invariant parameter ϕ_1 for each image shown in Fig. Q8, and give your comments on the results.

End