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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	:	**MEX5271 Machine Vision**
Academic Year	:	2015/2016
Date	:	**26th November 2016**
Time	:	**9.30am – 12.30pm**
Duration	:	3 hours

General instructions

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

Q1.

a) Discuss Human vision vs. Machine vision considering Decision making, Speed of response and Quality of measurements.
b) Discuss three reasons for Low Contrast images?
c) What is the object of applying Sharpening Filtering with respect to image processing?
d) Discuss the uses of Image Addition, Subtraction and Multiplication.

Q2.

a) An image has the histogram shown in Fig. Q2 (a). It is to be enhanced with histogram modification method to possess a desired histogram specified in Fig.Q2 (b). Sketch the resulting histogram of the image after the enhancement.

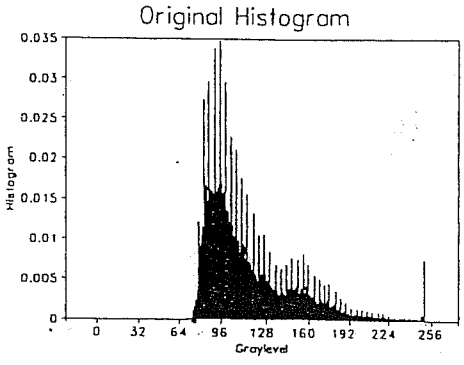


Fig. Q2 (a)

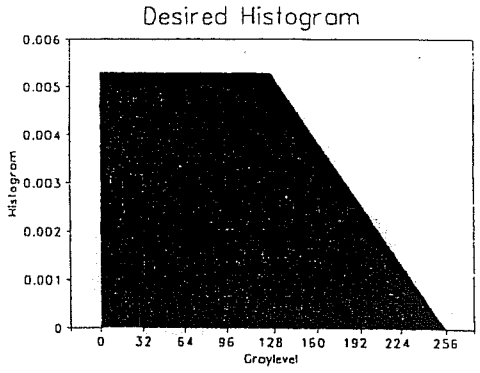


Fig. Q2 (b)

b) The gray level probability density function $p_r(r) = 3r^2$ of an image is shown in Fig.Q2(c). We wish to transform the gray levels of this image so that they will have the specified probability density function $p_z(z)$ given by the Rayleigh function given below. Assume the gray levels are continuous quantities, find the transformation (in terms of r and z) that will achieve this.

$$p_z(z) = \frac{z}{\alpha^2} e^{\left(-\frac{z^2}{2\alpha^2}\right)}$$ where α is a constant.

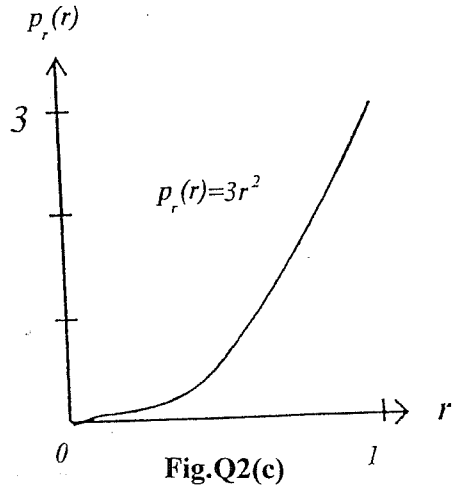


Fig.Q2(c)

Q3.

a) Fig.Q3 (a) shows a work piece placed on a horizontal table. With the aid of structure lighting, describe how you could determine the value of the angle α.

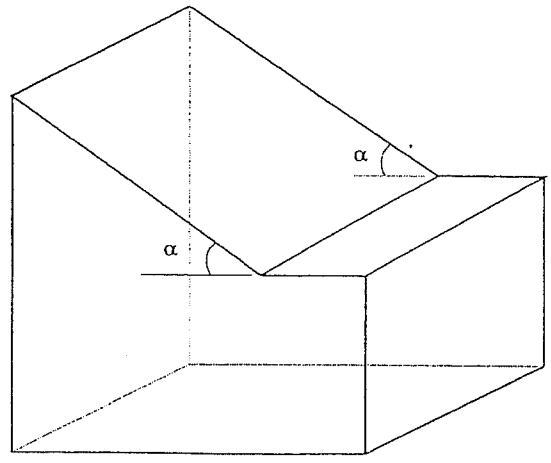


Fig.Q3(a)

b) 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 20μm, determine whether this system setup is suitable. Explain.

c) 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 an $f-$ 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.

Q4.

a) A and B are sets in 2-dimensional integer space $\mathbf{Z}^2$, show that

$$A \ominus B_x = (A \ominus B)_{-x}$$

$$A_x \ominus B = (A \ominus B)_x$$

b) In an image noise cleaning operation, a single pixel which does not have any 8-connected neighbour is considered as a noise spot. Design a morphological operation for the noise – cleaning operation. Clearly show the structure element used in the operation.

c) Fig. Q4 shows a digital binary image A, and two structural elements B and C. Determine the results of the following morphological operations.

(i). $(A \ominus B) \ominus C$

(ii). $A \ominus (B \oplus C)$

(iii). What conclusions can be drawn from the results of parts (i) and (ii)?

(iv). Show that $A \ominus C = (A \ominus C) \bullet C$. Explain whether this result is expected?

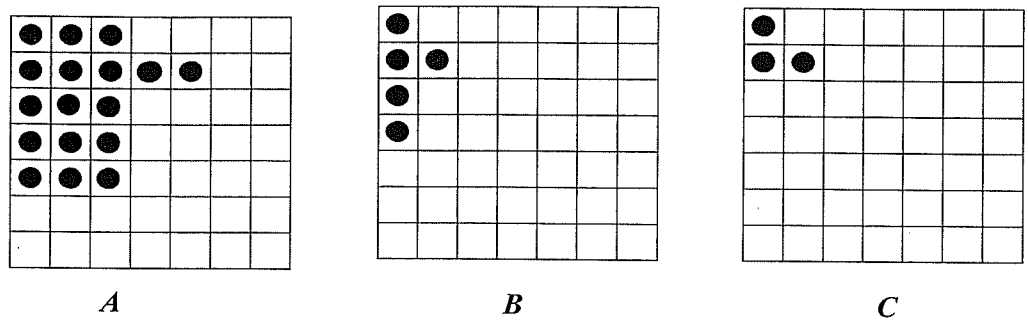


Fig.Q4

Q5.

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	01	13	01	00	04

Fig.Q5

Consider the 5×7 image shown in Fig.Q5 above, 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.

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).

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.

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.

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?

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?

Q6. Consider a given image $f(x, y)$, the gray level z of which lies within the interval **[a, b]** Mathematically:

$$\mathbf{a} \leq z = f(x, y) \leq b$$

for all **x**, **y** where **[a, b]** is a sub – interval of the available range of gray level ($[z_1, z_k]$) of the system used.

a) Find a simple linear gray level transformation expression that allows the stretching and shifting of the existing gray level interval **[a, b]** to occupy the full available range $[z_1, z_k]$.

b) Determine an expression that will stretch the gray level interval **[a, b]** to the full available range $[z_1, z_k]$, but compress the intervals $[z_1, \mathbf{a}]$ and $[\mathbf{b}, z_k]$.

c) Given a gray – level image, we wish to compress the gray level intervals **[0, 80]** and **[160, 240]** by a factor of **2**, and expand the gray level in the interval **[80, 160]** by a factor of **2**. Find the expressions for the required transformation. Be sure to indicate the valid range of each expression.

d) Suppose now we have an image with gray level ranges in the interval **[0, 30]**. Give the equations for the transformation that:

(i). Stretch the gray level interval **[0, 10]** into **[0, 15]**,
(ii). Shifts the interval **[10, 20]** to **[15, 25]**, and
(iii). Compress the interval **[20, 30]** into **[25, 30]**.

Be sure to indicate the valid range of each equation.

Q7.

a) A partial binary digital image is shown in Fig.Q7 (a), and the gray level **a** > **b**. Design a 3 by 3 mask, **G**, to detect the bright line with gray level '**a**', and produce an output image show in Fig.Q7 (b).

.... **b b b a b b b** ....

.... **b b b a b b b** ....

.... **b b b a b b b** ....

.... **b b b a b b b** ....

.... **b b b a b b b** ....

Fig. Q7 (a)

....	....	....	....	....	....	....
....	0	3(b-a)/2	3(a-b)	3(b-a)/2	0	....
....	0	3(b-a)/2	3(a-b)	3(b-a)/2	0	....
....	0	3(b-a)/2	3(a-b)	3(b-a)/2	0	....
....	....	....	....	....	....	....

Fig. Q7 (b)

b) Use the mask **G** developed in part (a) to process the partial digital images shown in Fig Q7 (c) and Fig Q7 (d), and show the respective output.

a	a	a	b	b	b
a	a	a	b	b	b
a	a	a	b	b	b
a	a	a	b	b	b
a	a	a	b	b	b

Fig. Q7 (c)

....	b	b	b	b	b	....
....	b	b	b	b	b	....
....	b	b	a	b	b	....
....	b	b	b	b	b	....
....	b	b	b	b	b	....

Fig. Q7 (d)

Comment on the effectiveness of the mask **G** that you developed in relation to the results obtained here.

c) Carry out the following processing:

- **(i).** Interchange the rows and columns of mask **G** to produce a new mask **H**.
- **(ii).** Convolve the partial image shown in Fig.Q7 (d), with the mask **H**.
- **(iii).** Convolve the partial image shown in Fig.Q7 (d), with the mask **G**.
- **(iv).** Do a point wise subtraction between the results of steps (ii) and (iii).

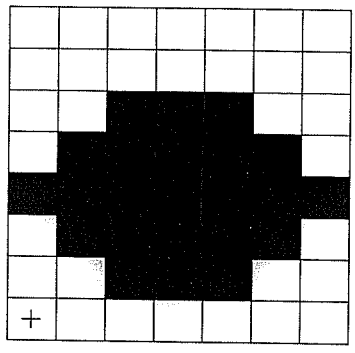
Show and discuss the result of step (iv). Suggest an application for this processing.

Q8.

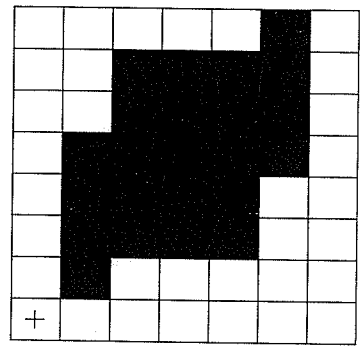
a) For a spatially discretised $M \times N$ image, denoted by $f(i, j)$, the p^{th} , q^{th} moment is given by :

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

Fig.Q8 shows images of an ellipse in 2 orientations formed by 7× 8 arrays of gray or white pixels. For each orientation, determine the moments 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 origin of the array is indicated by '+'.



(i)



(ii)

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. Calculate the values of μ_{02}, μ_{20} and θ of the two images shown in Fig.Q8, where θ is given by:

$$\tan 2\theta = \frac{2\mu_{11}}{\mu_{20} - \mu_{02}}$$

The values of μ_{11} for the regions shown in Fig.Q8 (i) and (ii) are, 0.0, and 24.0 respectively.

The second order central moment can be calculated with the following expressions:

$$\mu'_{20} = \frac{1}{2} \left(\mu_{20} + \mu_{02} + \sqrt{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}\right)$$

$$\mu'_{02} = \frac{1}{2} \left(\mu_{20} + \mu_{02} - \sqrt{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}\right)$$

Calculate μ'_{20} and μ'_{02}, for the region shown in Fig.Q8 (i) and (ii). Discuss what these two qualities represent with respect to the length of the major axes of the ellipse.