00061

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	:	2016/2017
Date	:	18th of November 2017
Time	:	9.30am – 12.30pm
Duration	:	3 hours

General instructions

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

Question 01:

Vision systems play a significant role in industry automation.

a) Explain the advantages of adopting vision based systems to industrial applications. (4 marks)

b) "Adoption of factory automation techniques must be done in a careful manner". Comment on this statement. (5 marks)

c) Briefly explain architecture of a machine vision system integrated in to a product assembly line of a manufacturing environment. (5 marks)

d) Briefly explain the situations where,

   i. Human Vision

   ii. Machine Vision

   Provides more accurate and reliable results. (6 marks)

Question 02:

Presence of noise in digital images is one of the major barriers which make image analysis process difficult.

a) Give three reasons for presence of noise in digital images. (3 marks)

b) Name three mechanisms which can be used to remove noise.. (3 marks)

c) Compare and contrast the methods mentioned in part (b). (4 marks)

d) Name a suitable noise reduction technique which can be used in real time image processing. Justify your answer. (5 marks)

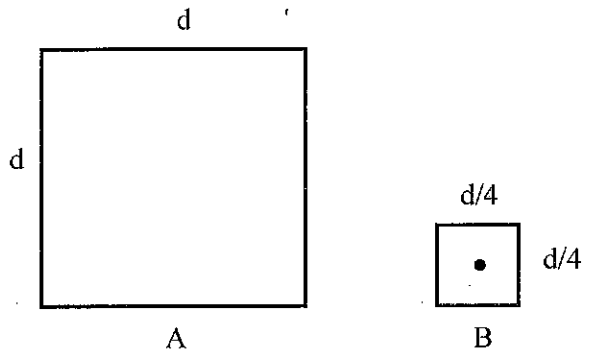
e) Write an outline of an algorithm to remove noise in digital images. (5 marks)

Question 03:

Most morphological operations are based on simple expanding and shrinking operations. The primary application of morphology occurs in binary images, though it is also used on gray level images. The two basic morphological set transformations are erosion and dilation.

a) Define dilation. State all assumptions clearly. (4 marks)

b) Show the result after dilation of object A by structural element B. (4 marks)



c) Define "Opening" and "Closing". State all assumptions clearly. (6 marks)

d) Briefly explain the practical usage of "Opening" and "Closing". (3 marks)

e) Give a brief account on "Hit or Miss Transformation". (3 marks)

Question 04:

a) Fig.Q4 (a) and Fig.Q4 (b) show the digital images of (a) a triangle, (b) an octagon, (c) an inverted triangle and (d) a pentagon. The moments m_{00}, m_{10}, m_{01}, m_{11}, m_{20} and m_{02} are given in the Table Q4. Use an intensity of 1 for gray pixels and 0 for white pixels. The '+' in the diagram indicates the origin (0,0)

If $\mu_{11} = m_{11} - \frac{m_{10}m_{01}}{m_{00}}$

$\mu_{20} = m_{20} - \frac{m_{10}^2}{m_{00}}$

$\mu_{02} = m_{02} - \frac{m_{01}^2}{m_{00}}$

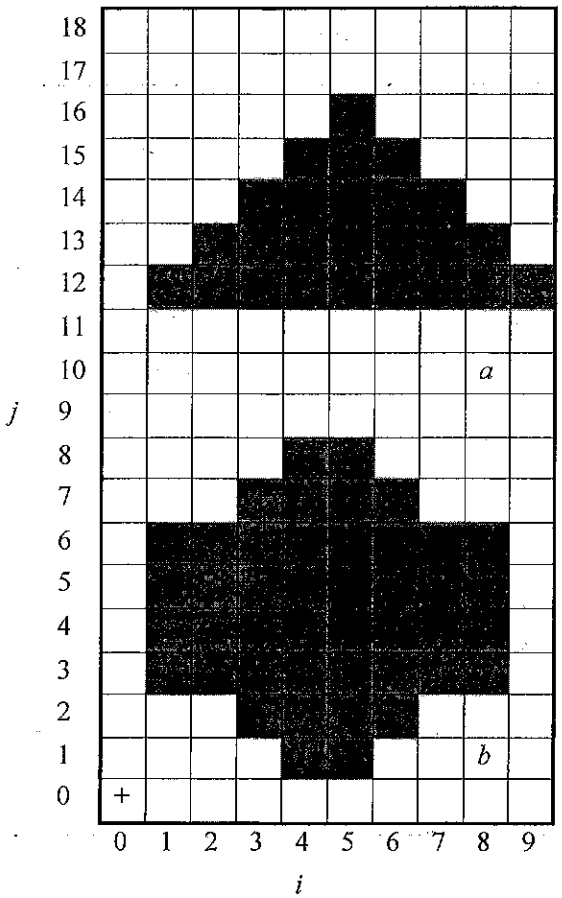


Fig.Q4 (a)

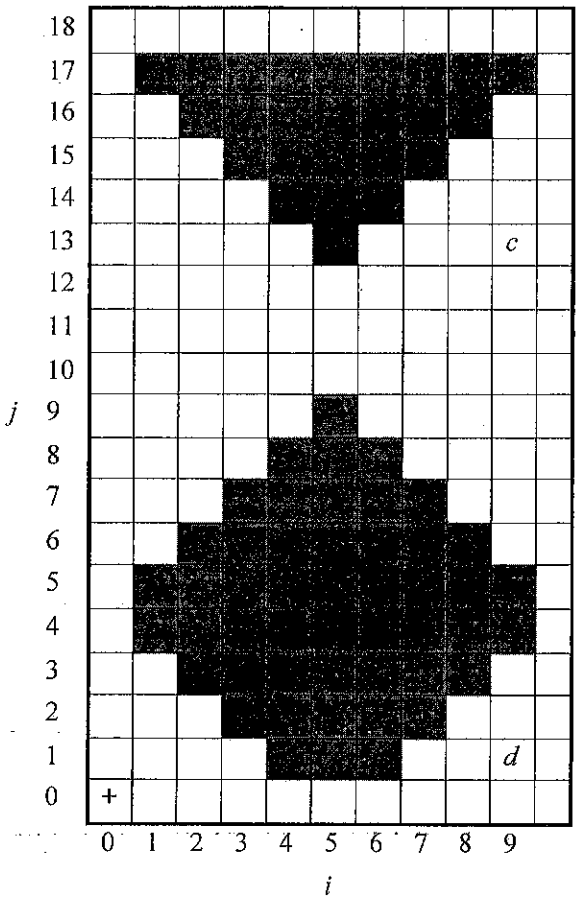


Fig.Q4 (b)

Then calculate the Central Moments μ_{11}, μ_{20}, and μ_{02}, for the four object images and comment on your values. (6 marks)

Diagram	m_{00}	m_{10}	m_{01}	m_{11}	m_{20}	m_{02}
Triangle (*a*)	25	125	330	1650	725	4390
Octagon (*b*)	44	198	198	891	1070	1030
Inverted Triangle (*c*)	25	125	395	1975	725	6275
Pentagon (*d*)	49	254	225	1125	1425	1225

Table Q4

b) Determine the Perimeter and the ratio Perimeter^2/Area for all the four object images. This ratio is known to be a measure of circularity or compactness of a shape, and assume its smallest value for circles (which is 4π). Based on the results that you have just obtained, comment whether this is still true in the case of digital images. (7 marks)

c) The coefficient ε is used as a measure of eccentricity of a digital image (0 for a perfect circle and 1 for a thin line).

$$\varepsilon = \frac{(\mu_{20} - \mu_{02})^2 + 4\mu_{11}^2}{(\mu_{20} + \mu_{02})^2}$$

Calculate ε for the four images. Do your results show that it is indeed a good measure of eccentricity of a digital image? (7 marks)

Question 05:

You use a microscope with its axis along the x-axis with a camera (with 256x512 pixels, frame rate 30Hz and f-stop 16) and a monitor (size 50x30 cm) to measure the size microbeams.

a) If the magnification between the monitor and workspace is 2500, what is the size of a pixel on the monitor and in the workspace? (3 marks)

b) You know that the microbeams are not larger than x = 50μm, y = 200μm and z = 30μm (1μm = 10^{-6} m). Determine the magnification which would provide the most accurate measurement. The entire beam must remain inside the image. (4 marks)

c) Do material irregularities of 1μm on the surface of the beam appear sharp on the monitor? (justify your answer with calculations) (4 marks)

d) Thermal noise disturbs the measurement. Propose a method to filter this noise without smoothing the image, assuming this noise is Gaussian (normally) distributed with zero mean. How much time does it require to reduce the standard deviation of the noise by a factor 100? (5 marks)

e) Explain why you would need a calibration and how you would perform it. (4 marks)

Question 06:

In a certain medical procedure, X-ray films were taken before and after injection of contrast medium (dye) into the arteries of a patient's heart. Radiologists are studying the films to determine whether coronary bypass surgery or heart valve replacement is required. Normally, they do digital image subtraction to visualise the dye as it fills the arterial passageways. In this case, however, problems in exposure and development of the two films make a direct comparison inconclusive. The patient is too weak to undergo the same procedure again. Only digital subtraction of the two images will reveal the extent of coronary disease.

To a good approximation, the histogram of the two images are given by the following distribution.

$$p(r) = \frac{r}{\alpha^2}\exp\left(-\frac{r^2}{2\alpha^2}\right)$$

Where $\alpha = 16$ for the first image and $\alpha = 32$ for the second image.

a) Determine the transfer functions that will equalise the two histograms. (6 marks)
b) Determine the transfer functions that will make the histogram to the post-injection image match that of the pre-injection. (9 marks)
c) Suggest a method that will improve the result of the digital image subtraction so as to obtain more conclusive results. (5 marks)

Question 07:

a) A photographer has taken the image below at night. 0 corresponds to black and 15 to white. In this image we can recognize one bright house in the left (the pixels with gray level >=8) and the moon on the right (the pixels with gray level <=6 and >=2). We want to extract a good image of the moon.

0	0	1	0	0	0	2	3	0
0	8	0	0	0	5	4	6	3
9	14	9	0	0	3	4	4	2
15	12	10	0	0	0	2	2	0
11	13	13	0	1	0	0	0	0

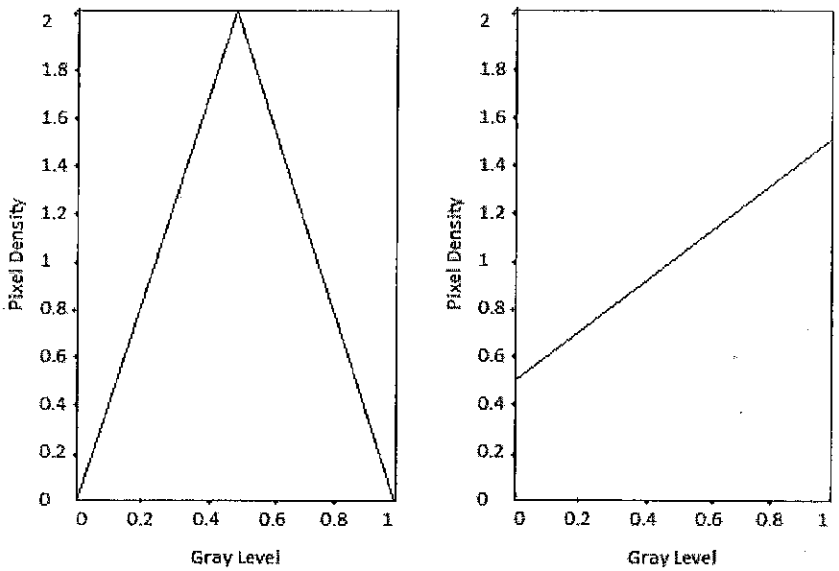
i. Perform the histogram of this image (3 marks)

ii. Design the point processing letting the moon unchanged and transforming the house and the background to black. (3 marks)

iii. Give the histogram of the negative of the image transformed after (ii). (3 marks)

b) To add contrast to the image resulting from a) ii, find the linear point processing that maps the gray levels on the moon to cover the full range of light intensities from 0 to 15. (5 marks)

c) The histogram of an image is pictured in Fig.Q7.(i). Give the point processing transforming this image in an image with the histogram of Fig.Q7.(ii).(6 marks)



(i) (ii)

Fig.Q7

Question 08:

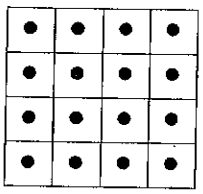
If **A**, **B** and **C** are sets in the 2-dimentional integer space $\mathbf{Z}^2$, prove the following relationships.

a) $A \oplus (B \oplus C) = (A \oplus B) \oplus C$ known as chain rule for dilation, (6 marks)

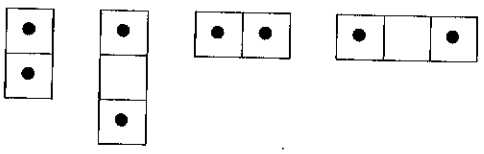
b) $(A \cup B) \oplus C = (A \oplus C) \cup (B \oplus C)$ (6 marks)

c) The two relationships in the parts (i) and (ii) are very useful in the decomposition of structuring elements by dilation and by union. Compare their efficiency in computing the dilations by using the two forms of structure elements **B** and **B'** as illustration in Fig.Q8. **B** is a 4x4 structure element, and **B'** is the decomposed structure elements of **B**. (8 marks)

(**Hint**: consider dilation of **A** by **B** as the union of translation of **A** by the elements of **B**.)



Structure element **B**



B' - Decomposed structure elements of B

Fig. Q8