First Semester Examination
2022/2023 Academic Session

February 2023

EPE 461 – Industrial Machine Vision
(Penglihatan Mesin Industri)

Duration: 3 hours
(Masa: 3 jam)

Please check that this examination paper consists of NINE (9) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi SEMBILAN (9) muka surat yang bercetak sebelum anda memulakan peperiksaan ini].

Instructions : Answer **ALL FIVE (5)** questions.

*[**Arahan :** Jawab **KESEMUA LIMA (5)** soalan.]*

…2/-

1. [a] Figure 1[a] shows an example of detecting a very long crack in concrete by processing 100s of patches on the image. State TWO (2) principle aims of the scene constraints and suggest the exploitation of the scene constraints.

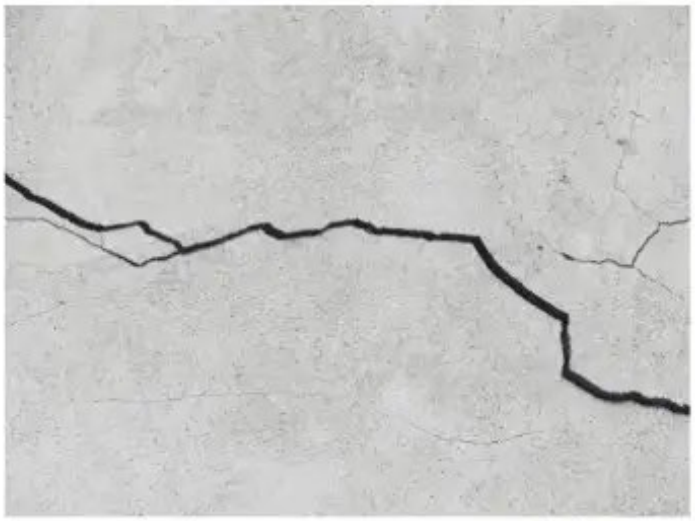

Figure 1[a]

(30 marks)

[b] Selia-Technology Sdn Bhd wants to implement a machine vision system on the needle inspection for packaging process. From Figure 1[b], list down THREE (3) defects that possibly happen during the inspection process.

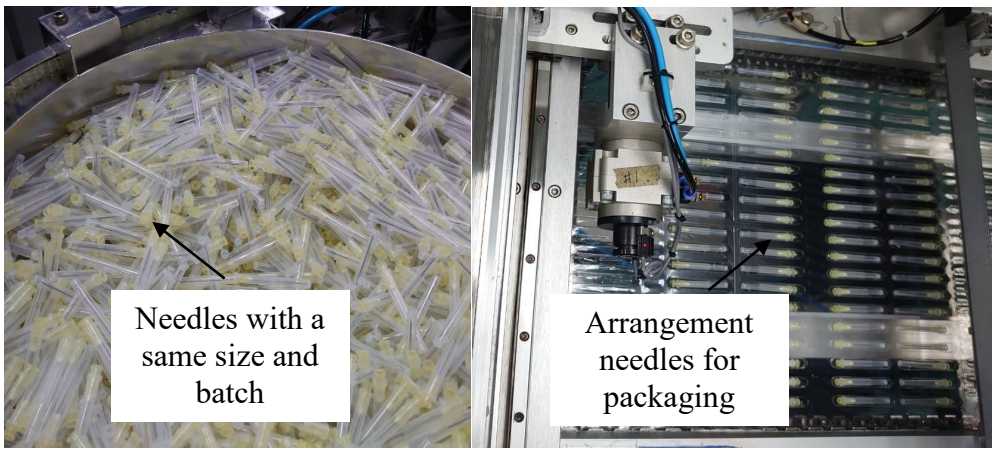

Figure 1[b]

(30 marks)

[c] Based on your knowledge and understanding of industrial machine vision, propose a vision system model to solve the issue mentioned in 1[b]. Use all the seven-element generic model for constructing the vision system model. Figure 1[b] is the detail of the needle stocks from the same size and batch that produce by Selia-Technology Sdn Bhd.

(40 marks)

2. [a] There are three illumination types in machine vision which are (a) low angle lighting (b) dome lighting and (c) coaxial vertical illumination. With the aids of suitable sketches, describe the principle of each illumination.

(30 marks)

[b] Suggest an illumination type to emit light evenly on the glossy surface of a spherical-shaped target as Figure 2[b]. Explain your answer briefly.

Figure 2[b]

(20 marks)

[c] The diagonal field of view (FOV) of the camera is determined by the focal length of the camera lens and the sensor size as illustrated in Figure 2[c]. Determine the field of view (FOV) in the Y direction of a macro lens with a 3x-optical magnification attached to a camera with a CCD size of 3.6 mm in the Y direction.

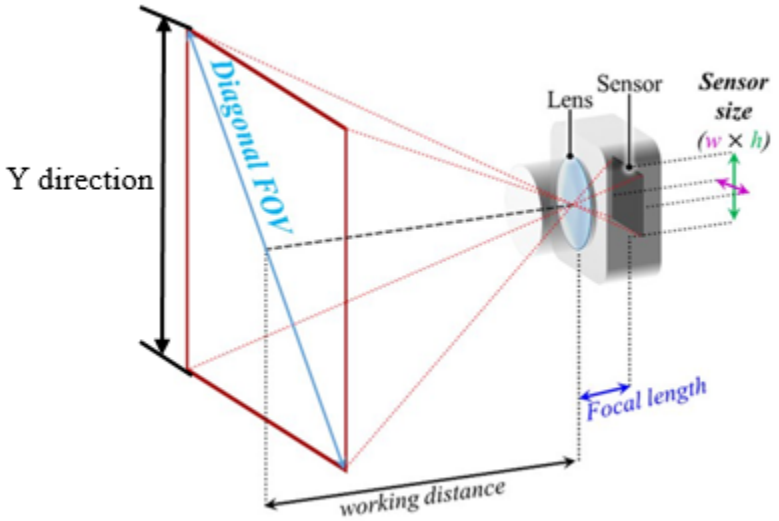

Figure Q2[c]

(30 marks)

[d] Determine the resolution of an image capture on a 48 mm field of view (FOV) using a CCD camera with size of 640 pixels width by 480 pixels height.

(20 marks)

3. [a] Briefly describe the significance of image enhancement and image restoration in the image pre-processing for a machine vision system.

(20 marks)

[b] Figure 3[b] shows the pixel values in an image array at a particular location. Determine the pixel value in the output image array at location (2, 3) if the image is processed using the following filters each:

(i) median filter with a 3×3 window

(ii) mode filter with a 3×3 window

(iii) average filter with a 3×3 window

(iv) range filter with a 3×3 window

…5/-

(v) k-nearest neighbour filter with k = 3 and a 3×3 window

Hence, comment on the noise suppression power of these filters based on the observation of the pixel location.

102	108	16	142
184	220	**198**	145
120	154	172	166
185	131	25	112

Figure 3[b]

(40 marks)

[c] Figure 3[c] shows the histogram of a 3-bit grayscale image of dimensions 8×8 pixels. Using the following mapping function for histogram equalization operation,

$$N(g) = \max\left\{0, Round\left(\frac{2^n \times c(g)}{p \times q} - 1\right)\right\}$$

where *n* is the bit depth of image, *c(g)* is the cumulative number of pixels counted up to gray value *g* and *p*×*q* is the size of image.

(i) determine the new gray values and plot the histogram resulting from the application of the operation. Show your working in a table.

(ii) state ONE (1) benefit of histogram equalization compared to pixel-wise brightness adjustment.

Figure 3[c]

(40 marks)

4. [a] Segmentation algorithms are based on one or two basic properties of intensity values: discontinuity and similarity. With a suitable sketch of line profile, explain the mechanism difference between image segmentation based on discontinuity and similarity.

(20 marks)

[b] The MATLAB script below can be used to partition an image into two regions, as shown in Figure 4[b](i).

```
1     I1 = imread('original.jpg');
2     I2 = I1;
3     [m,n] = size(I2);
4     for i = 1:m
5         for j=1:n
6             if I2(i,j) > 120
7                 I2(i,j) = 0;
8             end
9         end
10    end
```

…7/-

(i) Briefly explain the function expressed in the for-loop from line 4 to line 10.

(ii) Copy and modify the script so that it can be used to partition the "Original image" in Figure 4[b](i) into three distinctive regions. The histogram of the "Original image" is given in Figure 4[b](ii).

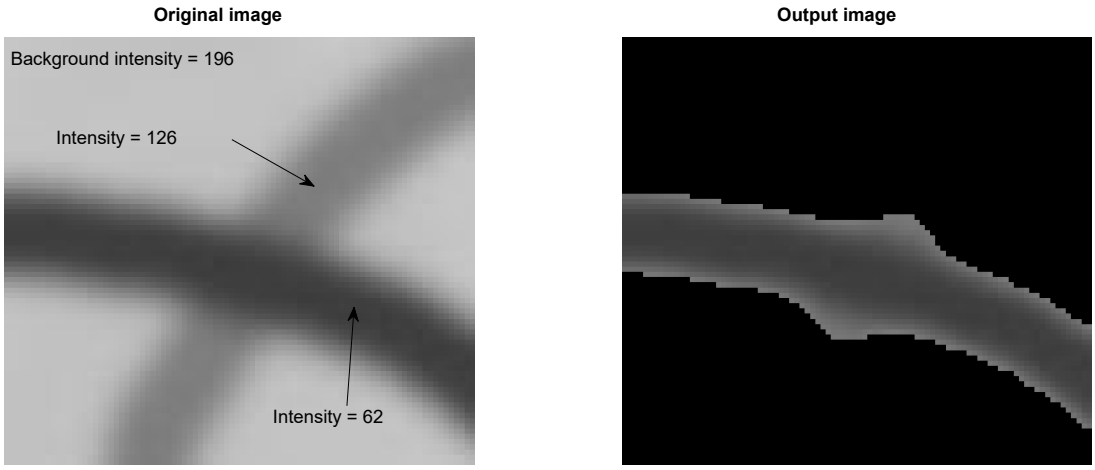

Figure 4[b](i)

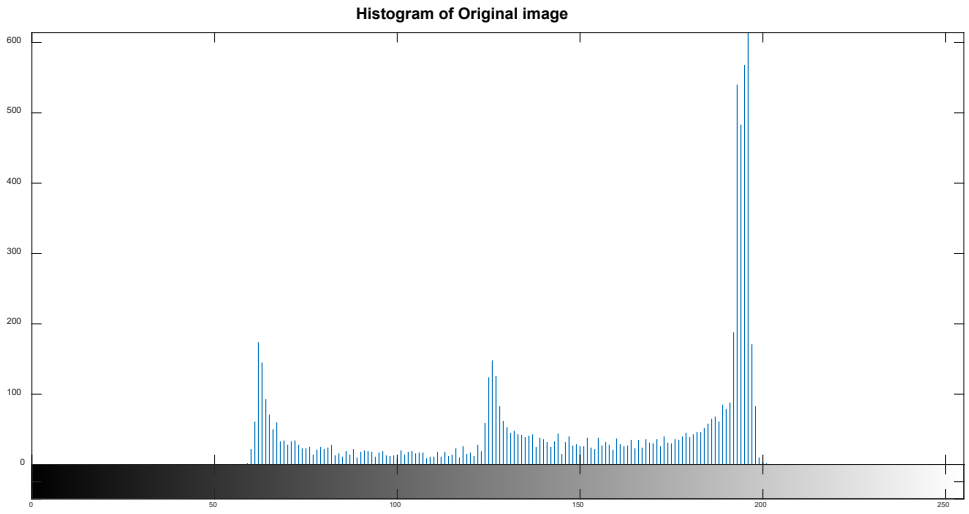

Figure 4[b](ii)

(50 marks)

…8/-

[c] Determine the run code for the image object as shown in the image below. Hence, based on the run code, determine the shape factor and centroid of the image object.

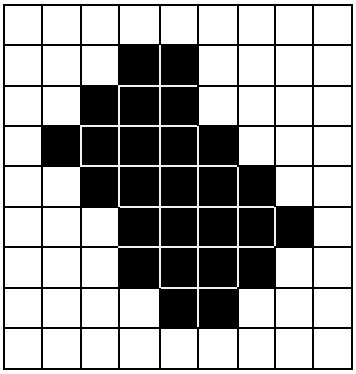

Figure 4[c]

(30 marks)

5. [a] Referring to a binary image array as shown in Figure 5[a](i), prepare the resulting correlation array for a template matching operation using a 3 × 3 template as shown in Figure 5[a](ii). Hence, determine the location of the object with the highest match in row and column.

0	0	0	0	0	0	0	0	1
0	1	1	1	0	1	1	1	0
1	1	0	0	1	1	0	1	0
0	1	1	1	0	1	1	1	0
0	0	0	1	0	0	0	1	1
0	1	1	1	0	1	1	1	0
0	0	1	0	0	0	0	0	0

(i)

1	1	0
1	0	1
1	1	1

(ii)

Figure 5[a]

(30marks)

[b] In a classification task, two prominent features were extracted from three representative patterns from three classes, as the following,

$$C_1 = \left\{\begin{pmatrix}1.175\\0.74\end{pmatrix}, \begin{pmatrix}1.2\\0.69\end{pmatrix}, \begin{pmatrix}1.2\\0.80\end{pmatrix}\right\}$$
$$C_2 = \left\{\begin{pmatrix}1.2\\0.60\end{pmatrix}, \begin{pmatrix}1.25\\0.57\end{pmatrix}, \begin{pmatrix}1.225\\0.50\end{pmatrix}\right\}$$
$$C_3 = \left\{\begin{pmatrix}1.275\\0.72\end{pmatrix}, \begin{pmatrix}1.25\\0.79\end{pmatrix}, \begin{pmatrix}1.275\\0.61\end{pmatrix}\right\}$$

…9/-

Given an unknown pattern with extracted features $\begin{pmatrix}1.215\\0.75\end{pmatrix}$,

(i) propose a suitable classification scheme that can be used for this classification task.

(ii) identify the class which the unknown pattern should belong to using the classification scheme proposed in (i). You must demonstrate the computation steps for the classification.

(40 marks)

[c] Given a confusion matrix below, in Table 5[c], determine and comment the performance of the classifier in corresponding to three classes, A, B and C in terms of recall, precision and F-score.

Table 5[c]

		Predicted class / *kelas dijangka*		
		A	B	C
Actual class / *kelas sebenar*	A	25	16	5
	B	12	37	5
	C	11	2	55

(30 marks)

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