First Semester Examination
2023/2024 Academic Session

Februari 2024

EPE 461 – Industrial Machine Vision
(Penglihatan Mesin Industri)

Duration: 3 hours
(Masa: 3 jam)

Please check that this examination paper consists of SIX (6) pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM (6) muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

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

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

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1. [a] Figure 1[a] shows an examples detection of a crack in an oil and gas industry pipeline. Determine TWO (2) principles of the scene constraints and suggest the exploitation of the scene constraints.

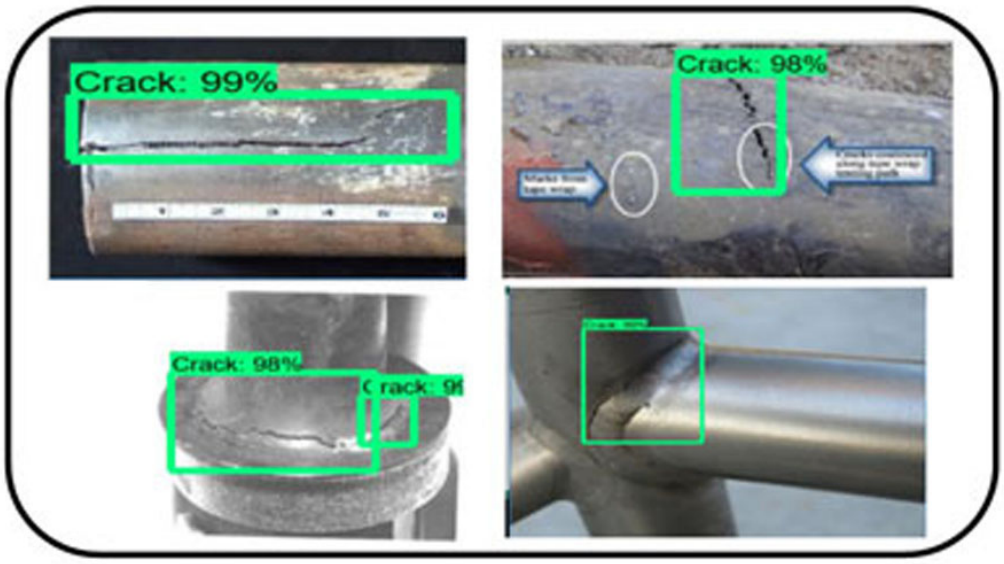

Figure 1[a]

(30 marks)

[b] Ayam Sons Sdn Bhd is looking to implement a machine vision system in their production line to segregate chicken parts after the cut-up process as shown in Figure 1[b]. The conveyor will transport the chicken parts, and the machine vision system will identify and classify them into respective categories. Based on your knowledge on machine vision, propose a lighting type and TWO (2) specific lens criteria for optimizing the system's execution.

Figure 1[b]

(30 marks)

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[c] Based on your knowledge and understanding of industrial machine vision, develop a vision system model to address the issue, utilizing the comprehensive seven-element generic model for constructing the vision system. Refer to Figure 1[b] for a detailed example related to Ayam Sons Sdn Bhd's production process.

(40 marks)

2. [a] To attain excellent image quality, it is essential to address several key variables. Identify THREE (3) crucial factors that significantly influence the overall image quality in your machine vision system.

(30 marks)

[b] Determine the sensor resolution of an image with a Field of View (FOV) of 48 mm (1.89") captured on a CCD camera with dimensions of 640 pixels in width and 480 pixels in length.

(20 marks)

[c] In a manufacturing setting utilizing a machine vision system for quality control on a conveyor belt, a shutter speed of 33.3 milliseconds is selected. Calculate the optimal frame rate and conveyor speed to ensure efficient inspection of rapidly moving products while preventing motion blur. Assume a constant product spacing of 0.2 m (the distance between two consecutive products on the conveyor). Examine the interplay between frame rate, shutter speed, and conveyor speed to optimize the machine vision system for quality control in this manufacturing process.

(50 marks)

3. [a] Briefly describe ONE (1) difference between Machine Vision and Computer Vision. Hence, describe the role of image processing in both areas.

(20 marks)

[b] Figure 3[b] shows the pixel values in an image array of 5 × 5 size.

102	108	134	142	123
184	16	196	145	187
167	154	172	166	176
185	131	122	21	135
156	148	178	166	154

Figure 3[b]

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(i) Given the one-dimensional Gaussian function as the following:

$$G(x) = \frac{1}{\sigma\sqrt{2\pi}} exp\{-x^2/2\sigma^2\}$$

Determine the kernel coefficients for a Gaussian filter with a 1 × 3 mask by taking standard deviation σ = 1.0. Show the pixel values in the output image array if the image is processed using the Gaussian filter.

(20 marks)

(ii) Prepare an output image processed using an average filter with a 1 × 3 mask. Hence observe the main difference on the greyed pixels between the images processed by the average filter and the Gaussian filter in (i).

(20 marks)

[c] Based on the image array as shown in Figure 3b, write a simple code to read all pixel values within the image array and perform binarization operation. Set the threshold value for binarization as 130. Hence sketch the output image after binarization.

(40 marks)

4. [a] With the aid of diagrams explain the basic principle behind 'unsharp masking'.

(20 marks)

[b] Three data points had been extracted from an image and plotted on a Cartesian plane as C (4, 14), D (8, 10) and E (16, 2). Using Hough transform technique,

(i) Determine the equation for each point in the Hough space in polar coordinates (r-ϕ) and plot the equations in the Hough space using graph provided.

(ii) Hence, prove that these three points are laid on the same straight line.

(50 marks)

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[c] Determine the run code for the object shown in Figure 4[c]. hence, using the run code, determine the centroid of the object.

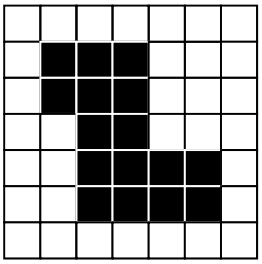

Figure 4[c]

(30 marks)

5. [a] In learning-based classification models, dataset is usually divided into for model train, validation, and testing. Briefly describe the role of each dataset when building a learning-based classification model.

(30 marks)

[b] In a classification task, two coded features, representing feature M and feature N, had been extracted from training instances and tabulated in Table 5[b]. Using the nearest neighbor classification technique, classify the unknown pattern, X (M = 245 pixel and N = 75) into its cluster. Show your computational procedure to achieve the classification.

Table 5[b]

Cluster	M	N
A	235	74
	240	69
	240	80
B	240	60
	250	57
	245	50
C	255	72
	250	79
	255	61

(40 marks)

[c] A novel impurity detection algorithm underwent evaluation and was benchmarked against human detection capabilities. In the initial comparison, the algorithm (denoted as A) successfully identified 900 impurities, whereas human inspectors (denoted as H_1) detected 400 impurities. Out of the 900 impurities identified by the algorithm, 350 were subsequently confirmed by human inspectors. This analysis revealed that

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50 impurities was undetected by the algorithm, while the remaining 550 detections were false positives. A follow-up investigation into the false positive identifications by human inspectors exposed that 300 out of the 550 instances (denoted as H_2) were indeed genuine impurities overlooked during the initial human inspection. The Venn diagram below provides a visual summary of the experiment's outcomes.

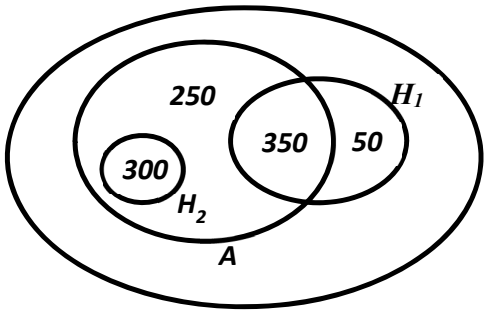

Figure 5[c]

(i) Based on information given, build the confusion matrix of the experimental result.

(ii) Determine the performance of the detection algorithm in terms of recall, precision, and misclassification rate.

(30 marks)

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