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91908

NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Digital Technologies and Hangarau Matihiko 2025

91908 Analyse an area of computer science

Credits: Three

Achievement	Achievement with Merit	Achievement with Excellence
Analyse an area of computer science.	Analyse, in depth, an area of computer science.	Critically analyse an area of computer science.

This assessment has TWO parts. Complete BOTH parts of the assessment.

Ensure that you have Resource Booklet 91908R.

You should aim to write **800–1,500 words** in total.

Excellence

TOTAL 08

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Make sure you have the paper Resource Booklet 91908R.

INSTRUCTIONS

This assessment has TWO parts. Complete BOTH parts of the assessment.

You should aim to write **800–1,500 words** in total.

Part One contains questions on three areas of computer science:

- Computer graphics
- Computer vision
- Complexity and tractability.

Choose only ONE area of computer science on which to answer questions. Enter the name of your selected area of computer science in the box below.

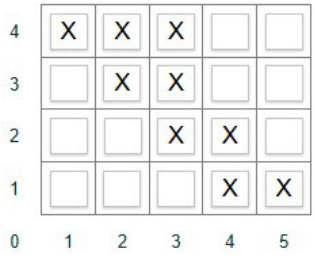
Computer Vision

Part Two has four questions. Answer all four questions.

Read both parts of this assessment before you begin your responses.

OR:

COMPUTER VISION



Consider that the matrix above has pixel values as follows:

[[10, 5, 5, 0, 0], [10, 10, 5, 0, 0], [10, 10, 10, 5, 0], [10, 10, 10, 10, 10]]

Use the pixel matrix provided above to answer part (a).

(a) (i) Illustrate the edges by marking them with Xs.

(ii) Describe how the change in pixel values facilitates edge detection in this specific instance.

Sobel algorithm is commonly used when you want to detect and find edges.
The main factor of the Sobel algorithm is finding gradient of the brightness. So, throughout this algorithm, using two matrixs to find it. The matrixs are 3*3 size, so i will chose the area (top left (2,4), bottom right (4,2)), then apply the weights of Sobel algorithm.

The first matrix of Sobel algorithm is below.
-1, 0, -1
-2, 0, -2
-1, 0, -1
and this is applied to the area that I choose
5, 5, 0
10, 5, 0
10, 10 ,5
Then this new matrix would be generated.
-5, 0, 0
-20, 0 , 0
-10, 0, -5
the sum of these numbers are -40

The second matrix of Sobel algorithm is below.
-1, -2, -1
0, 0, 0
-1, -2, -1
and when this is applied to the area that I choose,this new matrix would be generated.
-5, -10, 0
0, 0, 0
-10, -20, -5
the sum of these numbers are also -40

Gradient = arctan(-40 / -40) = pie/4 (45 degrees)
This is the gradient that brightness changes in the area. So the edge that we can see visually is the vertical to the gradient.
That's why the edge was illustrated from top left to bottom right.

Two images are taken simultaneously from a stereo camera set-up – one from the **left camera** and one from the **right camera**. These images capture the same scene from slightly different horizontal perspectives.

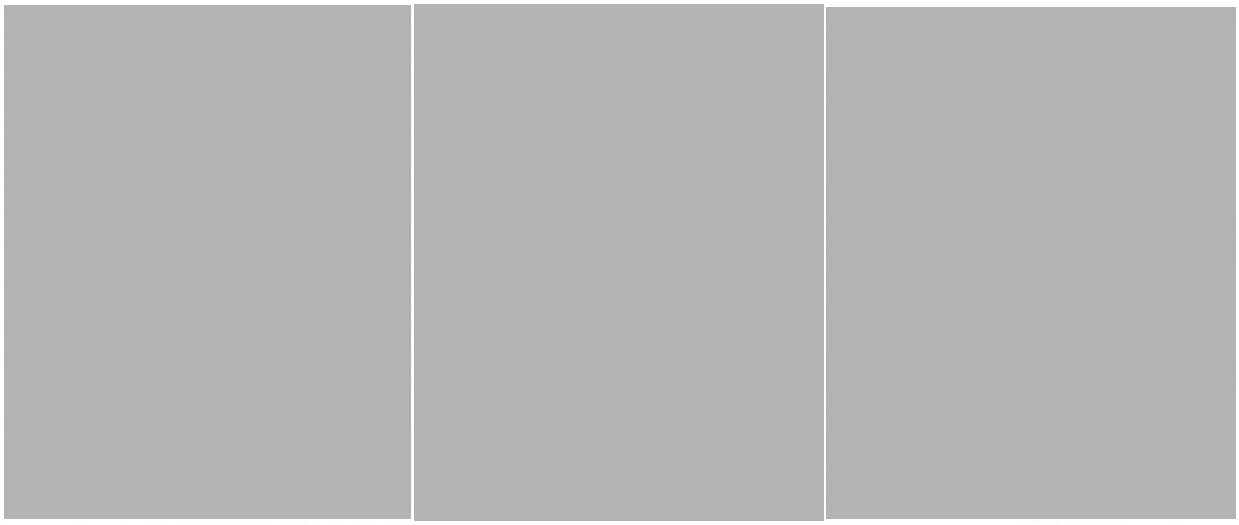
Source: https://people.duke.edu/~ng46/topics/stereo.htm

(b) Aside from the two images, identify and explain THREE key components or pieces of information required to compute a depth map using stereo vision.

To compute a depth, the equation blow is used.
Z = (f*B) / d
Z is the depth.
So the three key components required to calculate a depth are f, B, and d.
B is the baseline which is the distance between the two cameras.
f is the Focal length which is a certain number set when the image has taken, so when you want to know this number, you need to check the settings of the cameras.
d means the difference of the coordinates identified by two cameras. Since these two images have taken simultaneously from different places, the coordinates identified by two cameras are different. So you need to calculate this equation.
Rx (x coordinate from right camera) - Lx (x coordinate from left camera)

By finding these three components (numbers), you can compute and identify a depth map using stereo vision.

Use the images below to answer part (c).



Source: http://bit.ly/41j2T4C

Original image	Sobel / Prewitt algorithm	Canny edge detection

(c) (i) Complete the table above by identifying which image has likely used the Canny edge detection technique, and which has likely used another algorithm, such as the Sobel / Prewitt algorithm.

(ii) Explain what led you to make this decision.

In the process of canny edge detection, the image went through the some processes.
First, to reduce noises (to make subsequent process more effective), Gurssian filter which is one of the convolutional kernel is used.
Second, the sobel algorithm is used for emphasize edges in the image.
Sobel algorithm is also one of the convolutional kernel, and it has two matrixs (x direction, and y direction). Then when the matrixs are applied to an image, the edges in the image is detected. However, this includes the edge which is not the specific object, because Sobel algorithm detect location where the brightness changes rapidly.
Third, hysterical thresholding is used to identify only the edges of an certain object by set thresholds (higher one and lower one). If an edge is over the higher number, it would remain on the image. On the other hand, an edge which is lower than lower number would be deleted. And the rest of edges are classified whether they are connecting with strong edges.

So in the above image's case, in the second image from left, there are still many edges remeined even they are not the boundary of the dragon, such as sunlights and clouds. Therefore, this led me to identify that this image has likely used algorithms such as Sobel / Prewitt algorithms.
In the image on the right, the strong edges that is clearly the boundary of the dragon are remeined, which means this image has likely used the Canny edge detection technique which is often called the most optimal edge detection technique.

PART TWO

Refer to the resource booklet to answer parts (a), (b), and (c).

(a) Discuss the significance of your chosen area from Part One within the broader field of computer science. Why is it considered a critical component of the discipline?

Computer vision is essential for letting computer understand images or scenaries that we (humans) noemally see. To let it understand, computer can identify any objects' location, texture, color and so on like humans do. Therefore, it is considered that it is the important preprocessing for subsequent process or technology.

(b) Identify TWO specific algorithms or mechanisms that are central to your chosen area of computer science from Part One.

Algorithm or Mechanism 1: Canny edge detection

(i) Explain how your identified algorithm or mechanism functions, and discuss why it is important to the field.

Canny edge detection is one of the way of detecting edges from an image. This is used widely and sometimes called this is the optimal edge detection algorithm now.
Canny edge detection is structed in 3 steps.

1. Smoothing the image (Gurrasian filter)
   To achieve the accuracy edge detection, it doesn't want to be distrupted by noises. Therefore, using smoothing filter, such as Gurrasian filter will be useful and effective. The equation of Gurrasian filter is below.
   $\frac{1}{16} \times \begin{matrix} 1, 2, 1 \\ 2, 4, 2 \\ 1, 2, 1 \end{matrix}$
2. Emphasizing the edge (Sobel algorithm)
   After the smoothing the image, edges are detected by Sobel algorithm. The weights make the central pixel will be emphasize from surrounding pixels. At this step, the edges emphasized is not only the boundary of specific object, but also other places where the brightness chages rapidly.
3. Hysteric thresholding
   After detecting edges, it has to identify only the specific objects. So by using 2 thresholds (higher one and lower one), finding strong edges which is remeined in the image, medium edges which is classified whether they are connecting to strong edges, and lower edges which would be deleted.

As the Canny edge detection is called the optimal edge detection algorithm, this is so accurate, so the detected edges are used effectively in the subsequent technologies, such as autonomous driving system.

Algorithm or Mechanism 2: Viola-Jones and Haar-like features

(ii) Explain how your identified algorithm or mechanism functions, and discuss why it is important to the field.

Viola-Jones is a technique that is used widely for long time for detecting face. The Haar-like features are used during the Viola-Jones's process.

Haar-like features is used for extracting facial features by sliding 3 types of rectanglar features (below) entire the image. The features woukld detect places where the brightness changes.

- 2-Rectanglar features
  - The feature that divide the image in 2 rectangles like the third image from left in the top line in the RESOURCE E
  - E.g. Used for detecting the bridge of nose
- 3-Rectanglar features
  - The feature that divide the image in 3 rectangles like first, second and fourth image from left in the top line in the RESOURCE E
  - E.g. Used for detecting the boundary of the eyes
- 4-Rectanglar features
  - The feature that divide the image in 4 rectangles, and the feature that divide the image in 9 rectangles and has dot in the center like in the bottom line in the RESOURCE E

Using those features to detect facial features or landmarks and indentify whether it is face or not during the Viola-Jones.
The important thing when it comes to Haar-like features is integral image. This stores the sum of the pixel values from top left to that point, resulting in the ultra fast calculation even the features are slid all over the image in any sizes. If this technique doesn't be used, computer has to do thousands of processings to identify the facial features.

This Viola-Jones and Haar-like features is still used for detecting face (For example, the security of smartphone.), which is very important to this field of computer vision. And also the invention of integral image brought faster image processing and efficiency to the field.

(c) Explain how your chosen area of computer science from Part One is applied and implemented in a real-world scenario.

In your answer, provide detailed examples to show what this area of computer science can do and what its limits are.

In manufacturing process

There are manufacures that required less defects such as the manufacturere of some parts of car. Sometimes the products that manufactured is inspected by humans. However, sometimes the quality control don't work well because of the employees attitude or health.
To address this issue, the inspection machine which has stereo vision and edge detection algorithm will be the effective solution. This will capture the manufactured product like humas do by stereo vision, and the image taken by stereo vision will go through the edge detection, then inspect whether there are any crackings or defects. By implementing this machine, the company can inspect 24 hours, leading to increasing profits as well.
However if the machine got mistake such as finding products that are manufactured appropriately as a defects or missing the defects and they reach to end consumers. That's the limitation.

(d) Sometimes, technologies in this area of computer science can benefit certain groups of people while disadvantaging or negatively impacting others, either directly or indirectly.

Discuss how the issues and opportunities associated with your chosen area can impact society.

In the manufacturing process,
implementing high quality machine which inspect and find defects are so expensicve, so the company determined to implement the machine which is more cheaper, but less quality of the function. This might has a benefit to the company, because the budget is less preserved by choosing cheaper machine while implementing autonomous inspections. However, this machine has the high likelyhood of working incorrect, such as wouldn't find defects or find products that manufactured well as defects. This will let the products reach to market, and directly have bad impact on end users, leading to many compliments and recalls, so indirectly couses bad impact on support call organization. Eventually, it is likely to lost customer trust and the positon of the company in the market as well.

Excellence

Subject: Level 3 Digital Technologies

Standard: 91908

Overall grade: 08

Part	Question		Marker commentary
One (Computer vision)	(a)	(i)	*Illustrate the edges by marking them with Xs* • Correctly identified edge locations based on changes in pixel intensity in the given matrix.
		(ii)	*Describe how the change in pixel values facilitates edge detection* • Explicitly linked edge detection to gradients in brightness. • Correctly described the use of the Sobel operator, including convolution matrices and directional gradients. • Calculated gradients and explained how gradient direction relates to edge orientation. • Went beyond description to mechanism (convolution, gradient magnitude, direction). • Included correct numerical reasoning, reinforcing that edge detection is mathematical, not heuristic.

	(b)		*Stereo vision – components required to compute a depth map*
			• Identified three essential components:
			  ○ Baseline distance between cameras
			  ○ Focal length
			  ○ Disparity (difference in x-coordinates between images).
			• Used the correct depth relationship formula and explained the role of each variable.
			• Demonstrated systems thinking – depth is not a single value, but computed from multiple interdependent parameters.
			• Explanation connected geometry, camera configuration, and computation.

	(c)	(i)	*Identify which image used Canny vs Sobel/Prewitt* • Correctly identified the Canny edge detection image, based on edge quality and noise reduction. • Distinguished between dense, noisy edge output and refined object boundaries. • Used visual evidence to infer algorithm choice rather than naming features generically. • Showed understanding of algorithm outcomes, not just steps.

		(ii)	*Explain what led to the decision*
			• Correctly outlined the multi-stage Canny process:
			  ○ Gaussian smoothing
			  ○ Gradient detection
			  ○ Double thresholding and hysteresis.
			• Explained why Sobel / Prewitt detects too many irrelevant edges.

			• Explanation linked algorithm design to observable output. • Demonstrated comparison and evaluation, not just description.
Two (A broader computer science context)	(a)		*Significance of computer vision* • Positioned computer vision as a foundational pre-processing domain enabling higher-level interpretation. • Clearly linked perception, understanding, and decision-making. • Showed awareness of the role of computer vision within the wider discipline, not in isolation. • Used abstraction appropriately (vision as an enabling layer).
	(b)	(i)	*Algorithm 1* • Accurately explained each stage of the algorithm. • Included correct kernel values and linked smoothing to noise reduction. • Justified why Canny is considered 'optimal' for many applications. • Technically precise without unnecessary complexity. • Showed cause-and-effect reasoning (why each step exists).
		(ii)	*Algorithm 2* • Correctly explained Haar-like features and integral images. • Described how features are scanned across images at multiple scales. • Linked the algorithm to real-world face detection. • Demonstrated historical and practical understanding. • Explained efficiency, not just detection capability.
	(c)		*Real-world application and limitations* • Applied computer vision to manufacturing quality control. • Explained how stereo vision and edge detection are used in inspection. • Identified limitations, such as missed defects and system constraints. • Balanced discussion of capability and limitation. • Avoided overclaiming effectiveness, which is critical for Excellence.
	(d)		*Societal impacts – benefits and disadvantages* • Discussed economic and employment impacts of automation. • Identified trade-offs between efficiency and workforce displacement. • Explained the consequences for companies, workers, and consumers. • Showed ethical and societal awareness. • Directly addressed the 'benefit vs disadvantage' requirement, rather than simply listing the issues.