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3

91908

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.

Merit

TOTAL 06

Page 1

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

4	X				
3		X			
2			X		
1				X	X
0	1	2	3	4	5

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]]

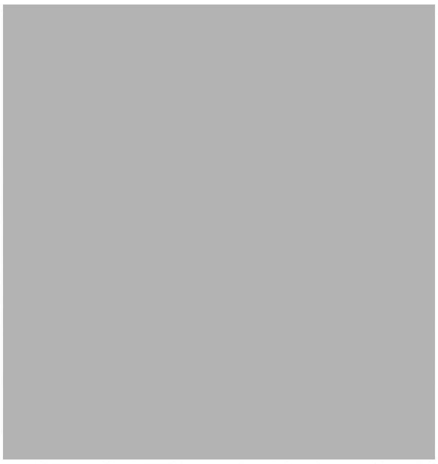
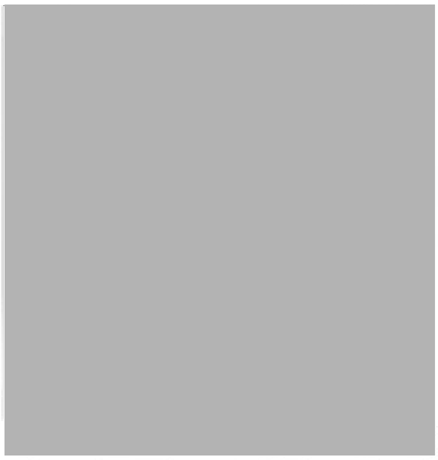
Use the pixel matrix provided above to answer part (a).

(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.

Edge detection identifies edges by comparing the 'intensity' of neighbouring pixels. If one pixel has a value 10 and the one next to it has a value 0 it shows there is a high contrast between these. If we find a line of such pixels with great differences we can follow the line and mark it as an edge. The contrast between the pixels sugguests there are two different things next to each other in the image, like two different coloured objects, or one object and the background, as these should have a difference in colour and light. Which is why the line of pixels with different values sugguests there is an edge.

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.

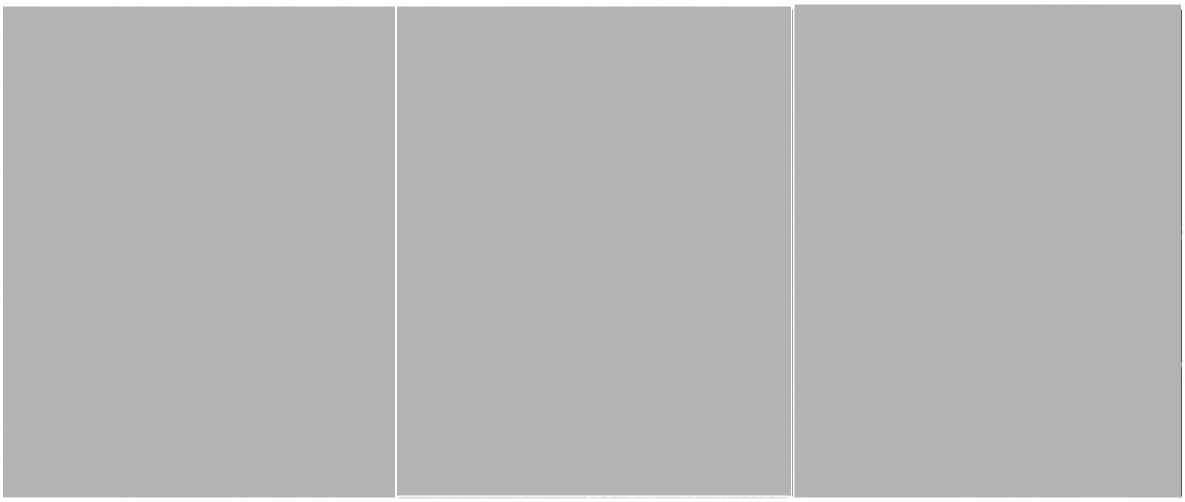
L   R

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.

In stereo vision we take two images and then compare the location of the same objects and pixels withing the two images, using triangulation we can find the depth of objects in the image. To identify the objects in the two images and compare them we need to use feature extraction, which can detect specifice shapes. This way we can identify and match the same objects from the two images. For feature extracion to work properly we need to have clear images where the outlines of shapes can be clearly seen. One component we use to simplify the images is thresholding. Thresholding compares every pixel in the image to a specific set value, if the pixel is below that value it will become a black pixel, if it is above the threshold value it becomes a white pixel. This simplifies the image into a binary black and white image which means the identification of the objects in the image can happen more effeciently and require less computation. However bad lighting can negatively effect thresholding, a spot with less lighting might be coloured in black which can confuse the feature extraction and make it think there is a dark object or wall where there isn't one. Another key component is noise reduction. Noise is random changes in pixels which make the image look more blury and makes it harder for algorithms to identify shapes and edges. Noise reduction sets all pixels' values to the average of the values of pixels around them. This eliminates random spots and dots that come from noise and make the image more clear, so it is easier for feature extraction to work.

Use the images below to answer part (c).



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

Original image	other 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.

As we can see in resource D canny edge detection mostly detects lines in the foreground of the image ignoring the messiness of the background. In inage 2 we can still see a lot of the background clouds and lines inside the image of the dragon, while in image 3 we can only see the dragon's outline and the background is set to black. Also in canny edge detection there is a binary image with only black and white while in image 2 we can see many shades of grey.

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 a very useful tool, and can be used together with artificial intellgience to solve many problems and greatly advance technology. For example, computer vision can be used for medical purposes such as identifying cancerous lumps. A convolutional neural network (resource C) can be trained with machine learning and a large dataset of labeled images to identify cancer in patiants. Using computer vision techniques we can get clear images and then use feature extraction and CNNs to identify cancer. This is very significant as it can take a long time to get an appointment with a doctor for check ups, and finding cancerous cells as soon as possible is critical and could help save many lives. Computer vision is also significant because it is a critical component for autonemous vehicles. If made right these vehciles could be more safe then human drivers and prevent car accidents. And to be able to drive well and safely these vehicles need to be able to see the road, identify other cars, speed signs, stop signs, traffic lights, pedestrians, all of this would require computer vision to detect all these objects and calculate their distance. So computer vision is critical for many new inventions and machines which are currently being devloped and that could have a great impact and computer sceince and society.

(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 (resource D) looks at the values of pixels in the image and looks for any intense changes in pixel value between areas of pixels. Specificly it looks for lines that have pixels with very different values on either side of the line. Such lines are called edges, they are the boundary between two object or between an object and the background. When all the edges in the image are found and mapped by canny edge detection we get a very simple image with straight lines marking the edges. This is very important because if we want an AI or CNN to be able to recognise shapes or objects, it would be quite difficault to do with all the noise and different pixel values in the original image. Whereas in edge detection only the lines of the edges are visible. When AI identifies an object in an image it looks for specific patterens of shapes, lines, and edges, these would be much easier to find after edge detection turns the image to only the lines that the AI is looking for. Edge detection simplifies and makes object detaction much more ffecient requiring less computation and less time. Being able to identify objects quickly can be very important, for example in an autonemous car where pedestrians and other cars need to be constantly identified in less then a second for the car to be able to drive safely, so saving time is critical, and edge detection speeds up and simplifies this process. Canny edge detaction is specificly useful since it focuses on objects in the foreground ignoring the background edges. In resource D the edges in the background between the mountains and the skies and the trees are mostly ignored, and the edges of the cat, the object at the foreground, are highlighted. This makes it easier to identify specific objects.

Algorithm or Mechanism 2: LiDAR

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

LiDAR is a system that maps out the distance from the system to all of the objects infront of it. LiDAR send out lasers which hit surfaces in front of the system and then bounce back, the time it takes the lasers to come back is used to then calculate the distance to what the lasers hit. Distance = (speed of light * time)/2. By calcualting the distance from each point the laser hit we can create a map of how far away everying infront of the system is. LiDAR can 'see' even in bad lighting and can extremly accurately show the distance to every object infront of the system, however it can be confuesed by rain, dust and glass, which might reflect the lasers and make the system think there is an object where there isn't one. Although LiDAR is expensive, and cannot actualy see colours and images, it is one of the most accurate ways to map out a surface, an area, or an object

(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.

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One example of a real word scenario where computer vision is used is autonemous vehicles. The vehicles need to be able to see the road and everyhing on and around it which is where computer vision comes in. Most autonemous vehicles use both LiDAR and stereo vision to get images. LiDAR sends out lasers which hit surfaces in front of the car and then bounce back, the time it takes the lasers to come back is used to then calculate the distance to what the lasers hit. Distance = (speed of light * time)/2. By calcualting the distance from each point the laser hit we can create a map of how far away everying infront of the car is. LiDAR can 'see' even in bad lighting and can extremly accurately show the distance to every object infront of the car, however it can be confuesed by rain, dust and glass, which might reflect the lasers and make the system think there is an object where there isn't one. LiDAR is also much more expensive then stereo vision and cannot see colours only distance. Stereo vision works by taking images from two cameras and then by comparing the differences in the location of objects in the two images, it's possible to calcualte the depth and distance of objects from the car. Stereo vision is much cheaper then LiDAR but less accurate and requires more computation to triangulate depth. It also does not work well in bad lighting. Using both of these systems means one can compensate for the weaknesses of the other and safety can be maximised. Once the image is taken it still has to be processed. Thresholding is used to create a simpler black and white image which is easier to analise. This is done by setting a threshold value, and then turning every pixel below the threshold value to black, and every pixel with a value above the threshold to white. This has some limits however, thresholding doesn't work well with bad lighting as it might colour a badly lit area in black, which might later be identified as an object even thou there is nothing there. Another weakness of thresholding is that if there is noise in the original image thresholding can make it worse. As we can see in resource F when thresholding is used on a noisy image the noise becomes worse, because all the pixels have been turned to either balck or white, instead of having some light or dark grey spots next to black and white ones,(from the noise) we now just have a bunch of black dots all over the image which makes it look more noisy. However if we use thresholding after clearing the noise from the image, as we can see in the bottom part of resource F, we can get a much cleaner sharper image. Noise reduction is an technique used to simplify the image and get rid of the noise. Noise is random changes in pixels which make the image look more blury and makes it harder for algorithems to identify shapes and edges. Noise reduction sets all pixels' values to the average of the values of pixels around them. This eliminates random spots and dots that come from noise and make the image more clear, so it is easier to process and analise. Edge detection is also used to simplify the image. Edge detection looks at the values of pixels in the image and looks for any intense changes in pixel value between areas of pixels. Specificly it looks for lines that have pixels with very different values on either side of the line. Such lines are called edges, they are the boundary between two object or between an object and the background. When all the edges in the image are found and mapped by edge detection we get a very simple image with straight lines marking the edges. Canny edge detaction (resource D) is specificly useful for this case since it focuses on objects in the foreground ignoring the background edges. In resource D the edges in the background between the mountains and the skies and the trees are mostly ignored, and the edges of the cat, the object at the foreground, are highlighted. This makes it easier to identify specific objects quicker. Once we have a simplified version of the image, feature extraction is used to identify shapes, lines, and corners. This is important for the next step. Then, CNNs are used to identify objects in the image. These CNNs were trained on large databases using machine learning so that they can see patterns of shapes and lines and use them to identify objects in images.The images go through the different layers of the CNN until it recognsies it as a specific object (resource C). This way the system identifies objects like cars, signs, traffic lights, and pedestrians. The CNNs have to be trained on large databases with no bias so they are able to identify every object in the image, otherwise the vehicle might crash into an object it failed to recognise. As CNNs that can identify objects related to driving are still limited in their ability it might take more time until autonemous vehicles can be safely implemented widely on roads.

(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.

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Computer vision is sometimes used in facial recognition. For example, some devices allow you to use face ID which lets you log in by showing your face to the camera. To identify that it is really your face devices use CNNs which have been trained on large databses of people's faces to be able to recognise human faces. However some face ID algorithems have problems with recognising faces of people with darker sikn. This is beacsue the databases that the CNNs have been trained on have a bias of showing more light skinned faces. This means that the CNNs are not as good at identifying dark skinned faces and often fail to do so which disavatnages a large number of people.

In medical imaging computer vision might be used to recognise cancerous cells, so it is very important that it gets the diagnostic correctly. If it falsely says the pateint does not have cancer when they actualy do (false negative) the pateint might decide to not have another check up with a doctor, it means the cancer would go undetected for longer and could potentialy harm patients. And if the system gives a false positive (it says the patient does have cancer when they really don't) it could cause much uneccesary stress. CNNs cannot alsways prefectly recognise objects/patterns in images, so it is very possible something like this happens and negatively effects people.

Autonemous vehicles (which use computer vision) could allow people who cannot physicly drive, becuase of blindness, paralisation, or severed limbs, to use cars and easily get places, which would have been more difficult or impossible for them with normal cars. However, autonemous cars could also cause taxi and uber drivers to lose their jobs, as companies might start using autonemous cars for taxi services. So computer vision can have both negative and poistive impacts on different people in society.

Merit

Subject: Level 3 Digital Technologies

Standard: 91908

Overall grade: 06

<table>
<tr><th>Part</th><th colspan="2">Question</th><th>Marker commentary</th></tr>
<tr><td rowspan="4">One
(Computer vision)</td><td rowspan="2">(a)</td><td>(i)</td><td>Illustrate the edges by marking them with Xs
Correctly identified most edge locations where pixel values change noticeably.
Xs were placed in appropriate regions, though edge placement was based more on visual pattern recognition than explicit reference to gradients.
Edge identification was mostly correct, but justification was implicit rather than explicit.
Demonstrated understanding of where edges are; a full explanation of why, in algorithmic terms, would have helped the candidate move towards Excellence.</td></tr>
<tr><td>(ii)</td><td>Describe how the change in pixel values facilitates edge detection
Explained that edges occur where there is a change in brightness or pixel values.
Mentioned an edge detection process (e.g. Sobel) in general terms.
Explanation showed conceptual understanding, but lacked detailed mathematical reasoning.
Limited or no worked example of convolution or gradient calculation.
Focused on description rather than mechanism.</td></tr>
<tr><td>(b)</td><td></td><td>Stereo vision – components required to compute a depth map
Identified key components, such as two cameras and disparity between images.
Explained that depth is calculated by comparing differences between left and right images.
Core idea of triangulation was understood.
Explanation was correct, but simplified; variables such as focal length or baseline were named, but without full explanation of their interaction.</td></tr>
<tr><td>(c)</td><td>(i)</td><td>Identify which image used Canny vs Sobel/Prewitt
Correctly identified the image produced using the Canny edge detection algorithm.
Decision was based on visual clarity and reduced noise.
Correct identification, but reasoning was brief and surface-level.
Relied on appearance rather than linking specific algorithm stages to the output, which was needed for a higher grade.</td></tr>
</table>

<table>
<tr><td></td><td>(c)</td><td>(ii)</td><td>Explain what led to the decision
Mentioned that Canny produces cleaner edges and removes noise, and referenced smoothing and thresholding in general terms.
Showed awareness of Canny’s multi-stage nature, but steps were not clearly sequenced or justified.
Explanation lacked the detail on hysteresis or gradient direction that was needed for Excellence.</td></tr>
<tr><td rowspan="5">Two
(A broader computer science context)</td><td>(a)</td><td></td><td>Significance of computer vision
Explained that computer vision allows computers to ‘see’ and understand images.
Identified it as important for recognising objects or scenes.
Correct and relevant, but generic.
Limited discussion of why computer vision is foundational within computer science as a discipline. More detail was needed for Excellence.</td></tr>
<tr><td rowspan="2">(b)</td><td>(i)</td><td>Algorithm 1
Identified a relevant algorithm and outlined its main purpose.
Described steps at a high level (e.g. smoothing, detecting edges).
Explanation showed understanding of what the algorithm does, but not how it works internally, which is needed for Excellence.
Lacked technical detail, such as kernel behaviour or gradient calculation.</td></tr>
<tr><td>(ii)</td><td>Algorithm 2
Identified a second relevant mechanism (e.g. facial detection).
Explained its purpose and gave a real-world use case.
Demonstrated relevance and application.
Limited discussion of efficiency, optimisation, or computational strategy.</td></tr>
<tr><td>(c)</td><td></td><td>Real-world application and limitations
Applied computer vision to a realistic context, such as manufacturing or inspection.
Identified at least one limitation (e.g. errors, missed defects).
Application was appropriate and clearly linked to the chosen area.
Limitations were acknowledged, but not deeply analysed or quantified enough for Excellence.</td></tr>
<tr><td>(d)</td><td></td><td>Societal impacts – benefits and disadvantages
Identified benefits such as efficiency and accuracy.
Recognised disadvantages such as cost or job displacement.
Balanced response, with both positive and negative impacts.
Discussion was descriptive rather than evaluative; impacts were not explored in depth; a lot of repetition of knowledge.</td></tr>
</table>