Calculators may be used in this examination provided they are not capable of being used to store alphabetical information other than hexadecimal numbers

UNIVERSITY OF BIRMINGHAM

School of Computer Science

Robot Vision

Main Summer Examinations 2023

Time allowed: 2 hours

[Answer all questions]

Turn Over

Note

Answer ALL questions. Each question will be marked out of 20. The paper will be marked out of 60, which will be rescaled to a mark out of 100.

Question 1

Most of the algorithms developed in the field of Computer Vision and Imaging are inspired by something that works well in nature.

(a) Using illustrations of an array of Ganglion cells, explain how the human eye detects edges in images. **[3 marks]**

(b) Name four factors that cause discontinuity in intensities, which leads to edges appearing in images. **[2 marks]**

(c) You are presented with the image below, where you are required to detect the edges using a kernel efficiently. What would be the kernel you would choose, and why? **[3 marks]**

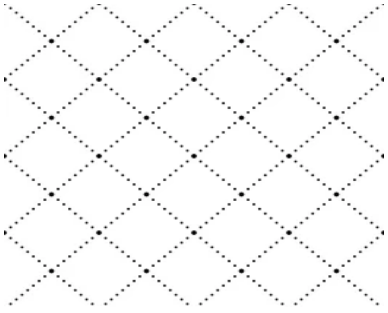


Figure 1: Image for detecting the edges

(d) Canny is a standard edge detector available in many software platforms and libraries. Write the four stages of the Canny edge detection algorithm explaining the operation with equations or illustrations as needed. **[8 marks]**

(e) Compare the Canny edge detection with the Sobel operator, stating an advantage and disadvantage of each method. **[4 marks]**

Question 2

The equation to calculate the output dimension of a convolutional layer is given below:

$$S_{out} = \left\lfloor \frac{S_{in} + 2 \times padding[0] - dilation[0] \times (kernel_size[0] - 1) - 1}{stride[0]} + 1 \right\rfloor \quad (1)$$

Consider an input image of size 288×344 (H=288, W=344), and a simple convolutional neural network (Conv1→Conv2→Pool1→Conv3) defined as:

Conv1: kernel size 5×5, padding 2, stride 1, dilation 1; **Conv2**: kernel size 3×3, padding 1, stride 2, dilation 2; **Pool1** (average pooling): kernel size 2×2, stride 2; **Conv3**: kernel size 3×3, padding 0, stride 1, dilation 1.

(a) Please answer if the above network can be used to do a classification problem (i.e. classify the given image to a particular category). **[2 marks]**

(b) Give an explanation of why (i.e. if Yes, why? or if No, why?) and a detailed demonstration on the above example. **[9 marks]**

(c) If the answer to the above question is "Yes", what is the final output dimension? If the answer is "No", how to modify the network to achieve the goal (i.e. image classification with 10 classes)? **[9 marks]**

Question 3

(a) Most of the smartphones available today come equipped with a panorama shooting function. You may have used this feature while travelling or when trying to capture a beautiful scenery. This feature is based on the image stitching method we have learned. What are the potential reasons why a smartphone may fail to generate a satisfactory panorama image? Provide at least three reasons, and explain how each reason affects the generation of the panorama image. **[9 marks]**



Figure 2: Example of a forward-facing stereo cameras system

(b) Recently, many cars are equipped with forward-facing stereo cameras, which are used to make cars smarter.

(i) Describe at least two smart functions that are made possible when the stereo camera system is installed in a car like Figure 2. **[4 marks]**

(ii) Despite their usefulness, stereo cameras have certain limitations and constraints. In order to overcome these limitations, other auxiliary sensors such as ultrasonic or LIDAR are often used in conjunction with the stereo camera system. Can you identify at least two limitations or problems that arise when relying solely on the stereo camera? Please explain your answer based on the characteristics of the stereo camera that we have learned in this module.
[7 marks]

End of Paper

This page intentionally left blank.

Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or Tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.