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

Computer Vision and Imaging

Main Summer Examinations 2023

Time allowed: 2 hours

[Answer all questions]

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]**

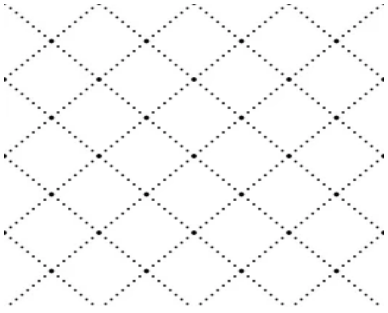

Figure 1: Image for detecting the edges

(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

You are asked to design and implement a visual vehicle identification system by superstore, which needs to track vehicle traffic to its car park. The system must be able to identify each individual car entering or leaving through an authorised access point and based on the vehicles registration number to associate the vehicle with the arrival and departure time from the car park. You should describe the technique that you would apply together with the problems you believe you would encounter in such a system so that you can:

(a) Gather the required information for processing. **[2 marks]**

(b) Identify each individual vehicle. You need to outline the details of your chosen method that will allow make this possible. **[10 marks]**

(c) Determine and minimize the drawbacks of the suggested technique. **[8 marks]**

End of Paper

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.