CE316-6-AU

UNIVERSITY OF ESSEX

Undergraduate Examinations 2019

COMPUTER VISION

Time allowed: **TWO** hours

Candidates are permitted to bring into the examination room:

Calculator — Casio FX–83GT PLUS or Casio FX–85GT PLUS **only**

The following items are provided:

Graph paper (available on the invigilator's desk)

The paper consists of **FIVE** questions.

Candidates must answer **Question 1** in **Section A** and **three** questions in **Section B**.

All questions are of equal weight.

The percentages shown in brackets provide an indication of the proportion of the total marks for the **PAPER** which will be allocated.

Please do not leave your seat unless you are given permission by an invigilator.
Do not communicate in any way with any other candidate in the examination room.
Do not open the question paper until told to do so.
All answers must be written in the answer book(s) provided.
All rough work must be written in the answer book(s) provided. A line should be drawn through any rough work to indicate to the examiner that it is not part of the work to be marked.
At the end of the examination, remain seated until your answer book(s) have been collected and you have been told you may leave.

SECTION A

Candidates must answer ALL questions in Section A.

Question 1

(a) Sketch a histogram of the 4-bit image shown in Figure A1.1. From it, determine whether it is under-exposed, over-exposed, or well-exposed. **[5%]**

0	4	4	3	2	1	1	0	3	0
1	4	6	7	2	5	5	1	4	2
4	5	10	6	3	4	6	5	6	1
2	3	4	8	12	10	4	5	4	2
4	2	1	0	15	6	2	7	4	3
6	3	5	4	3	1	3	3	4	5
4	5	2	8	2	5	1	4	5	6
3	2	4	2	3	4	2	1	0	4
2	4	1	3	6	5	3	2	1	3
4	2	0	5	3	6	4	2	3	6

Figure A1.1

(b) A sphere of known diameter is placed in a scene and imaged by a vision system. Discuss briefly whether one can determine the distance to the sphere from a single image, or whether one must have a stereo vision system in order to determine its distance. If a single image is enough, state what ancillary data would be needed. **[5%]**

(c) Cop dramas on TV often have experts who are able to take grainy images in which a car number plate fills only a handful of pixels and ‘zoom in’ to read it. Discuss whether this is possible in real life. **[5%]**

(d) Outline briefly the major stages in John Canny’s edge detector. **[5%]**

(e) Describe the purpose of a POOL layer in a convolutional neural network. **[5%]**

END OF SECTION A

SECTION B

Candidates must answer THREE questions in Section B.

Question 2

(a) What is corner detection in computer vision? Why is it so widely used? **[5%]**

(b) The operator due to Moravec is widely used for detecting edges. Describe the major stages of this operator. **[10%]**

(c) If `im[y,x]` is an image indexed by `y` (row) and `x` (column), write an implementation of the Moravec corner detector. Your answer should be given in pseudo-code. Marks are allocated for a clear exposition of the algorithm rather than the syntax of your pseudo-code. **[10%]**

Question 3

A computer vision system is being developed to process rocks extracted from a diamond mine. Raw diamonds are indistinguishable from ordinary rock, both being light grey in colour and having similar texture. However, ordinary rocks from the mine are roughly spherical while raw diamonds are much more jagged.

(a) Assuming the rocks taken from the mine are scattered across a black conveyer belt, describe briefly a suitable set-up for capturing images and any processing that would yield connected-component regions in images suitable for distinguishing raw diamonds from rocks. **[8%]**

(b) Describe a way of describing the shape of the connected regions that would allow you to distinguish raw diamonds from rocks. **[10%]**

(c) If three other developers have each devised alternative vision systems that use different ways of describing shape, outline briefly a way of ascertaining which is the most effective. **[7%]**

Question 4

A mobile robot equipped with a pair of cameras is being developed for use in a robot football competition. The cameras are identical and oriented so that their optical axes are parallel. The football pitch is green with black goals, and is surrounded with white walls. Lines on the pitch are red and the corner markers blue. The ball is orange.

(a) How can the ball be segmented in imagery captured by the camera? **[5%]**

(b) Describe a way that allows the centre of the ball to be located. **[5%]**

(c) If the positions of the centre of the ball in the image from the left- and right-hand cameras are x_L and x_R, derive an expression that allows the distance Z to the ball to be determined. **[10%]**

(d) The focal length of the cameras is (35 ± 0.01) mm and they are separated by (90 ± 1) mm. If $x_L = 100$ and $x_R = 88$, determine the distance to the ball and its uncertainty. **[5%]**

Question 5

(a) A software developer is developing a security system for laptops which uses face recognition to authenticate the user. Describe briefly how face recognition systems work. **[7%]**

(b) Two candidate face recognition algorithms are evaluated on the same face dataset and the false and true positive rates shown in Table B5.1 are obtained as a threshold is varied. Draw the receiver operating characteristic (ROC) curves for the two algorithms on the same axes. **[10%]**

false positive rate	true positive rate (algorithm A)	true positive rate (algorithm B)
0.17	0.47	0.58
0.33	0.61	0.72
0.50	0.82	0.74
0.67	0.92	0.80
0.83	0.97	0.82
0.95	0.98	0.86

Table B5.1

Hence explain which algorithm would be the more appropriate for the task.

(c) Describe any shortcomings of this security system. **[8%]**

END OF PAPER CE316-6-AU