CE316-6-AU

UNIVERSITY OF ESSEX

Undergraduate Examinations 2018

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) Convolve the image shown in Figure 1.1 with a 3×3 blur mask, calculating the sum at each pixel. You should perform cyclic wrap-around at the edges. **[5%]**

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

Figure 1.1

(b) Photography packages such as *Photoshop* are able to 'stitch' automatically a set of images whose fields of view overlap into a panorama. Describe briefly how these panorama creation facilities must work. **[5%]**

(c) The Canny edge detector involves a thresholding step that uses *two* thresholds. Explain why two thresholds are involved. **[5%]**

(d) A system is being developed that detects cancerous lesions. Two competing algorithms, A and B, have been developed to do this and their *Receiver Operating Characteristic* (ROC) curves are shown in Figure 1.2. Explain which algorithm would be more suitable. **[5%]**

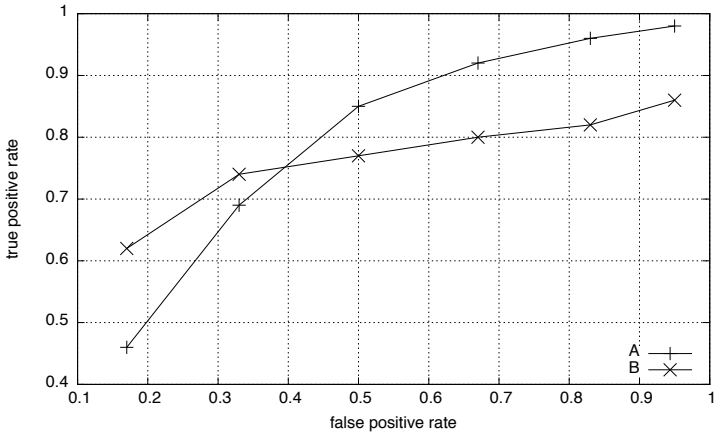

Figure 1.2

Question 1 continues...

Question 1 (continued)

(e) A convolutional neural network normally contains a "fully-connected" layer immediately before its output stage. Explain the purpose of this layer. **[5%]**

END OF SECTION A

SECTION B

Candidates must answer THREE questions in Section B.

Question 2

A low-resolution infra-red sensor is mounted in the ceiling of a supermarket, pointing downward so that it can record images of people queueing for the checkout. The grey-level values of an image captured by the sensor, showing three people in the queue, are given in Figure 2.1 below.

1	2	5	2	0	3	4	2	6	5	2	3	0	0	2	1
3	1	4	4	3	1	2	2	4	6	0	2	1	5	1	0
6	3	1	5	1	2	1	4	2	3	0	1	10	2	3	3
1	10	1	1	0	2	3	3	4	6	8	4	2	5	1	2
10	14	1	10	11	1	14	1	3	2	6	2	3	0	1	1
15	10	1	13	10	1	15	6	12	3	1	3	5	3	0	2
10	10	1	12	15	1	15	13	3	4	2	4	2	1	3	3
10	1	1	9	10	2	3	2	4	2	3	5	3	0	1	2
1	2	5	2	0	3	4	2	6	5	2	3	0	0	2	1
3	0	2	3	3	4	6	1	4	4	1	2	1	4	2	3
6	3	1	5	0	1	8	2	3	3	3	1	2	2	4	6
1	5	1	1	8	4	2	5	1	2	0	2	1	5	1	0

Figure 2.1

(a) Determine and sketch the histogram of this image. From it, identify a way of segmenting people from the background. **[12%]**

(b) When the queue has four or more people in it, the supermarket managers want to alert available checkout operators automatically to open up a new till. Based on your answer to (a), describe in detail a way of achieving this using computer vision. **[13%]**

Question 3

A mobile robot equipped with a camera is being developed for use in a robot football competition. The football pitch is green with black goals, and is surrounded with low white walls. Lines on the pitch are red and the corner markers are blue. The ball is orange. Spectators surround the pitch and there is no control over the colours of their clothes.

(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) Describe in detail a mechanism that would allow the ball to be distinguished from any similarly-coloured regions on spectators' clothes. **[15%]**

Question 4

You have been employed by Wivenhoe Innovative Systems Engineering (WISE) to help them with the design of a vision system that captures accurate models of human faces, with application in reconstructive surgery of recovering cancer sufferers. WISE aims to use a computational stereo rig with two identical cameras to determine facial shape in 3D.

(a) With the aid of a diagram, obtain an equation that allows the distance to features observable in both cameras to be determined. Be sure to state any assumptions made. **[10%]**

(b) WISE's system has two cameras of focal length 15 mm arranged 9 cm apart. Images contain 640×480 pixels and the pixel size in the detectors is 0.1 mm. If the disparity of a point on a face is about 100 pixels in the two cameras, determine whether the system is able to determine depth differences to 1 mm. (Hint: what does a one-pixel difference in disparity correspond to?) **[15%]**

Question 5

Local binary patterns (LBP) have become a popular feature detector for some aspects of computer vision.

(a) Explain the particular type of feature that LBPs are normally used to describe. **[5%]**

(b) Describe the steps that are used to calculate the LBP descriptor. **[10%]**

(c) Using well-commented pseudo-code, present a routine for computing the contribution to the descriptor around a single pixel located at (x_c, y_c). **[10%]**

END OF PAPER CE316-6-AU