CE316-6-AU

UNIVERSITY OF ESSEX

Undergraduate Examinations 2014

Computer Vision

Time allowed: **TWO** hours

Candidates are permitted to bring into the examination room:

Calculators (hand-held, containing no textual information)

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) A photographer has captured a digital image that shows little contrast, except for a few pixels which are very bright. Explain what simple image processing technique could be used to improve the appearance of the image. **[5%]**

(b) You have been asked to advise on the development of an application that centres around the accurate detection of corners in images. The developers are considering supporting the BMP, JPEG, PNG and TIFF image formats. Discuss which of these should be supported, and explain why any of them should not. **[5%]**

(c) The grid of numbers in Figure 1.1 represents part of an image. **[5%]**

	1	1	1	1	1	1	
	1	1	-5	5	-5	1	
	1	1	1	1	1	1	

Figure 1.1

Where possible, calculate the resulting values when this part of the image is median filtered by a 3×3 blur mask.

(d) 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%]**

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

END OF SECTION A

SECTION B

Candidates must answer THREE questions in Section B.

Question 2

An autonomous spacecraft is being developed to deliver supplies from the ground to the International Space Station. The spacecraft is equipped with a pair of cameras to help the docking process, using a target consisting of concentric circles to help the incoming spacecraft.

(a) Describe briefly a way that allows the centre of the docking target to be located. **[5%]**

(b) If the positions of the centre of the docking target 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 target to be determined. State any assumptions you have made. **[12%]**

(c) The focal length of the cameras is (100 ± 0.1) mm and they are separated by (200 ± 0.4) mm. If $x_L = 100$ mm and $x_R = 88$ mm, determine the distance to the target and its error. **[8%]**

Question 3

(a) Sobel's detector is widely used for detecting edges in images. Explain briefly how it works, including both the convolution masks it uses and a description of the convolution process. **[10%]**

(b) For a real-time application, it is desired to calculate the output of the Sobel operator as rapidly as possible. Show how the number of multiplications involved can be greatly reduced when calculating the response to the convolution masks. **[5%]**

(c) When processing 640×480-pixel images at 20 frames per second, determine whether your speeded-up version of Sobel is able to operate in real time on a processor that performs additions and multiplications in 0.01 μs. **[5%]**

(d) For images that have been segmented so that objects appear white and the background black, discuss whether Sobel's edge detector is the best way of identifying the boundaries of objects. **[5%]**

Question 4

(a) Explain what is meant by *tracking* in computer vision. **[5%]**

(b) Describe in detail how *gradient descent tracking with prediction* works. **[10%]**

(c) When tracking a 3D object performing out-of-plane rotations, its appearance will change from frame to frame. Discuss whether this is a problem for a gradient descent tracker and how it can be accommodated in practice. **[10%]**

Question 5

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 5.1 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 5.1

(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%]**

END OF PAPER CE316-6-AU