CE316-6-AU

UNIVERSITY OF ESSEX

Undergraduate Examinations 2013

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) Cop shows on TV often have experts that 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%]**

(b) SIFT, the *Scale-invariant Feature Transform*, can be used to identify the same points on objects on multiple images, irrespective of scale or orientation differences. Describe briefly one application which makes use of this ability. **[5%]**

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

(d) It is normal to evaluate vision algorithms using a database of images for which the correct results are known. When performing each test, four possible outcomes are possible; describe briefly what they are. **[5%]**

(e) Sketch a histogram of the 4-bit image shown in Figure A.1. From it, determine whether it is under-exposed, over-exposed, or well-exposed.

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 A.1

[5%]

END OF SECTION A

SECTION B

Candidates must answer THREE questions in Section B.

Question 2

The process of following the motion of features from frame to frame is known as *tracking*.

(a) Outline the tracking technique known as *hierarchical tracking*. Discuss whether it is likely to be better suited to a real-time vision system than *exhaustive search* tracking. **[10%]**

(b) A feature of size 16×16 pixels is being tracked in images of size 512×512 pixels.

(i) How many pixels have to be processed when performing an exhaustive search for the feature in the image? **[5%]**

(ii) If the image is sub-sampled for hierarchical tracking three times and the final image searched exhaustively, roughly how many pixels have to be processed when searching? **[5%]**

(c) If a particular computer is able to process 500,000 pixels per second, discuss whether either exhaustive search or hierarchical tracking will be able to operate at 10 frames per second. **[5%]**

Question 3

A mobile robot is constructed with a pair of identical cameras of focal length $f = 50 \pm 0.1\,$mm mounted on the corners of the front of the vehicle. The cameras are oriented so that their optical axes are perfectly parallel, separated by a distance $B = 100 \pm 2\,$mm, and point directly ahead. The robot is stationary and both cameras observe an object travelling towards the robot.

(a) If x_L and x_R are the positions of the object in the left and right images, with the aid of a diagram show that the distance to it can be calculated using

$$Z = \frac{fB}{x_L - x_r}$$

[10%]

(b) If the values of x_L and x_R in successive frames are as shown below in Table B3.1, calculate using the expression derived in (a) the distance to the object in these frames and their errors. You should use your experience of computer vision to estimate the likely error in x_L and x_R.

frame	x_L	x_R
0	100	88
1	68	53
2	25	-3

Table B3.1

[6%]

(c) Hence, determine whether the object is moving in a straight line. **[9%]**

Question 4

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 5

(a) Describe how the process of *convolution* with a set of coefficients is performed. Explain how convolution is used in *matched filtering.* **[5%]**

(b) The image of Figure B5.1 shows a region of the wall of a biological cell. This cell wall is covered with 'bumps' with the appearance of having been illuminated from the lower right of the image. With explanations, design a set of coefficients that isolate and emphasise these features.

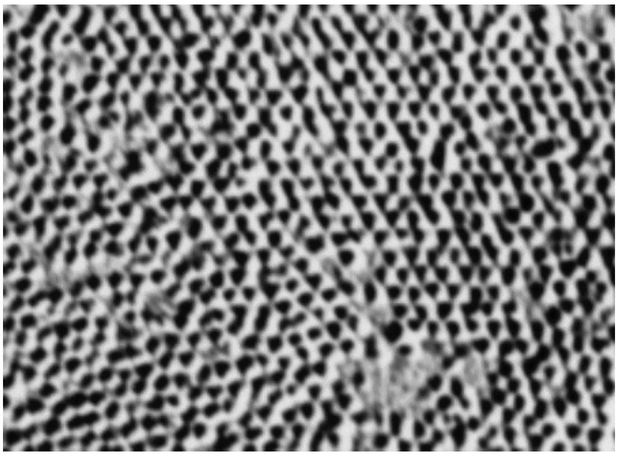

Figure B5.1

[8%]

(c) Show that applying your set of coefficients to the region of the image represented in Figure B5.2 does indeed emphasise the 'bump.'

10	10	10	10	10	10
10	10	0	0	10	10
10	10	0	50	20	10
10	10	10	20	20	10
10	10	10	10	10	10

Figure B5.2

[7%]

(d) Explain what will happen if a single bump on the image has two visible peaks. How might you guard against this in your analysis of the image? **[5%]**

END OF PAPER CE316-6-AU