CE316-6-AU

UNIVERSITY OF ESSEX

Undergraduate Examinations 2015

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 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) 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 convolved with a 3×3 blur mask.

(b) Outline briefly the principles of the Moravec corner detector. **[5%]**

(c) Outline briefly five applications of image processing and computer vision where tracking plays an essential role. **[5%]**

(d) A system is being developed that controls access to a restricted area using face recognition. 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%]**

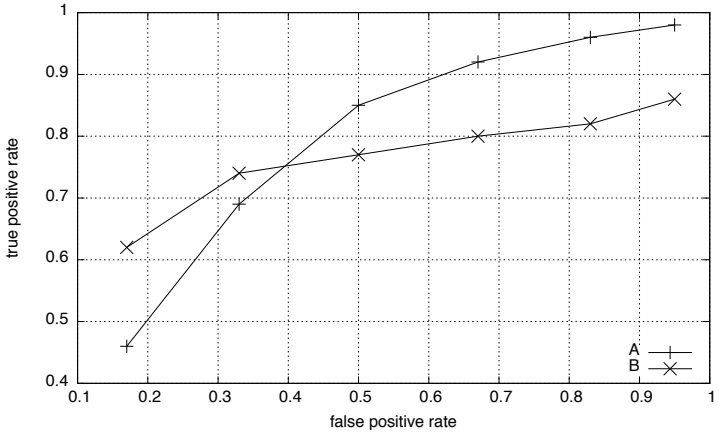

Figure 1.2

(e) An image feature is being tracked in an image sequence. In five frames, it has moved linearly from $(100, 100)$ to $(140, 130)$. Predict where it will appear in the next frame. **[5%]**

END OF SECTION A

SECTION B

Candidates must answer THREE questions in Section B.

Question 2

One of the most popular techniques for improving low-contrast regions in images for visual presentation is *histogram equalisation*.

(a) Describe the stages in performing histogram equalisation. **[10%]**

(b) Given a one-channel image, `im[x,y]`, with 8-bit pixels, write in pseudo-code a procedure that performs histogram equalisation. **[15%]**

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 10 mm arranged 8 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

Locating faces in images is a common computer vision task.

(a) As skin has a characteristic colour, a reasonable approach would seem to be to search images for pixels having that colour. Identify two problems with this approach. **[8%]**

(b) The algorithm due to Viola and Jones makes use of *Haar features*. Describe briefly what a Haar feature is, illustrating your answer with examples. **[9%]**

(c) Although in widespread use, the Viola-Jones algorithm has some practical shortcomings. Describe briefly the two most significant of these. **[8%]**

END OF PAPER CE316-6-AU