CE316-6-SP

UNIVERSITY OF ESSEX

Undergraduate Examinations 2020

COMPUTER VISION

Time allowed: **TWO** hours (exam time) + **ONE** hour to allow for submission time (total **THREE** hours)
(Please see your exam timetable or check on FASER for the deadline to upload your answers)

The times shown on your timetable are in British Summer Time (BST) (GMT+1). Please check online for a conversion to your local time if you will be undertaking your assessment outside the United Kingdom.

Candidates are permitted to use:

Calculator — Casio FX–83GT PLUS/X or Casio FX–85GT PLUS/X **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.

If you have a query with the content of this exam paper please use the revision FAQ Forum on the module's Moodle page. Your academic will be available to answer any queries in real-time.

If you have a technical problem with FASER, or any other query, please go to the Exams Website to find contact details of the teams that can help you.

Please note that the time allocated for this assessment includes time for you to download this question paper and answer paper and to upload your answers to FASER.

Please allow at least 30 minutes at the end of your exam time to upload your work. Once you have completed the assessment do not leave it to the last minute to upload.

Please save your work throughout the examination to avoid losing your work. Please do not communicate with any other candidate in any way during this assessment. Your response must be your own work. Procedures are in place to detect plagiarism and collusion.

SECTION A

Candidates must answer ALL questions in Section A.

Question 1

(a) A developer intends to use matching the histograms of images as a way of performing content-based image retrieval. Discuss briefly whether this approach is likely to work. **[5%]**

(b) Outline briefly the principle of the FAST corner detector, and hence explain whether it is able to operate at video rates. **[5%]**

(c) Otsu's method is widely used in computer vision. State its purpose and give any shortcomings it may have. **[5%]**

(d) Outline briefly a way of determining whether a region found in an image is circular. **[5%]**

(e) A *convolutional neural network* is built up from five types of layers. Describe briefly what these layers do. **[5%]**

END OF SECTION A

SECTION B

Candidates must answer THREE questions in Section B.

Question 2

A local company, Wivenhoe Innovative Software Engineering (WISE), has appointed you as a consultant because of the extensive knowledge of computer vision you have gained from CE316. WISE is developing a vision-guided robot system for a warehouse to manipulate parcels for shipment. All the parcels in the warehouse are shipped in dark red cardboard boxes.

(a) What advice would you give WISE regarding how the walls and shelving in the warehouse are painted and the lighting arranged? **[9%]**

(b) If you were able to configure the vision system in the robot in any way you wish, describe two ways in which parcels might be segmented from the surroundings. **[6%]**

(c) Describe a simple way in which the shape of features resulting from the segmentation process can be identified as being rectangular. **[10%]**

Question 3

Convolution is widely used in computer vision.

(a) Explain how the convolution process works. **[8%]**

(b) A particular vision system segments objects from their background, resulting in images which contain white objects of value unity on a background of value zero. Such an image is shown in Figure 3.1 below. **[10%]**

0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	1	0	0	0	0
0	0	0	1	1	1	1	1	0	0
0	0	1	1	1	1	1	1	0	0
0	0	1	1	1	1	1	0	0	0
0	0	0	1	1	1	1	0	0	0
0	0	0	0	0	0	0	0	0	0

Figure 3.1

Using a 3×3 mask with all its coefficients set to unity, pass the mask over the image in the usual way for convolution but calculating the minimum value at each location rather than the conventional sum. Compare the image after convolution with the original image and explain what this process does.

(c) From your answer to (b), identify a way of isolating the boundaries of objects in these kinds of binary images. **[7%]**

Question 4

Face recognition is a well-known application of computer vision.

(a) What is meant by *enrolment* in a face recognition system? **[5%]**

(b) When a person enrols in a face recognition system, it is normal to use several images of their face rather than a single one. Explain why this is the case. **[5%]**

(c) In the particular case of the *eigenfaces* technique, what is stored when a person is enrolled? **[7%]**

(d) When a person is compared against enrolled faces in eigenfaces, how is that comparison performed? **[8%]**

Question 5

A mobile robot is equipped with cameras at its front two corners; a schematic plan view is shown in Figure 5.1. Two identical cameras of focal length f are arranged so that their optical axes are perfectly parallel and separated by a distance B.

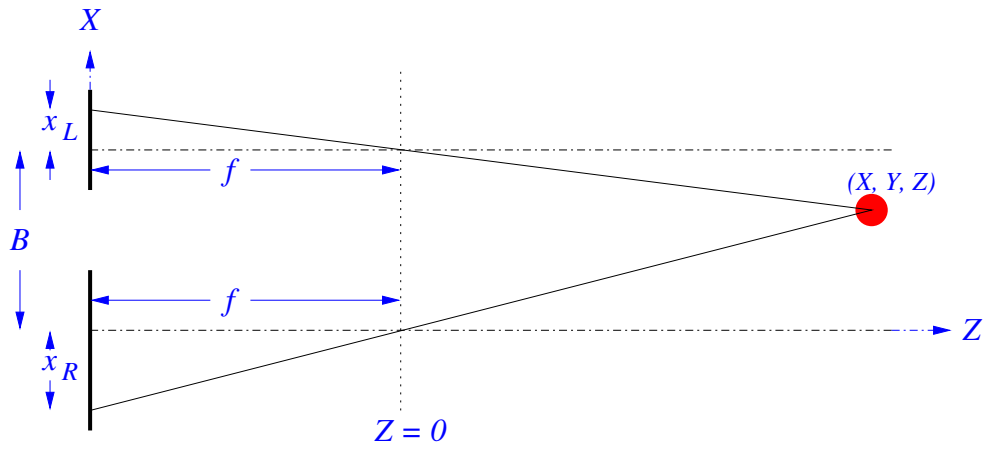

Figure 5.1

(a) Show that the distance Z to an object visible in both camera images is given by: **[10%]**

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

where x_L and x_R are the x-locations of the object in the left and right images respectively.

(b) In the case where $B = 80\,\text{mm}$, $f = 50\,\text{mm}$, $x_L = 12\,\text{mm}$ and $x_R = -12\,\text{mm}$, calculate the distance Z to the object. **[5%]**

(c) If a second pair of images were taken and it was found that $x_L = 8\,\text{mm}$ and $x_R = -8\,\text{mm}$, what can you infer about the motion of the object? **[10%]**

Once you have completed your answers, please upload them to FASER
http://faser.essex.ac.uk

Remember to add your REGISTRATION NUMBER onto ALL documents that you upload.

END OF PAPER CE316-6-SP