

**CARDIFF UNIVERSITY
EXAMINATION PAPER**

Academic Year: 2009–2010
Examination Period: Spring
Examination Paper Number: CM0311
Examination Paper Title: Image Processing
Duration: 2 hours

Do not turn this page over until instructed to do so by the Senior Invigilator.

Structure of Examination Paper:

There are 4 pages.

There are 4 questions in total.

There are no appendices.

The maximum mark for the exam paper is 60, and the mark obtainable for a question or part of a question is shown in brackets alongside the question.

Students to be provided with:

The following items of stationery are to be provided:
ONE answer book.

Instructions to Students:

Answer 3 questions.

The use of translation dictionaries between English or Welsh and a foreign language bearing an appropriate school stamp is permitted in this examination.

- Q1. (a) Optical illusions demonstrate that the human visual system uses many assumptions (i.e. expectations or prior knowledge) to facilitate perception by effectively employing heuristics. Describe one such optical illusion and the heuristic involved. [4]
- (b) Briefly describe a commercial application of computer vision (what it does and how it does it), outlining the benefits of a computer vision solution over traditional systems. [4]
- (c) Describe one example of distortion in the image that can be caused by the camera during the acquisition process. How can the image be processed to correct for the distortion effects? [4]
- (d) Describe two possible models of **connectedness** used in binary images, outline the problems involved. [4]
- (e) The image of circular rings shown below on the left has been resized by subsampling to produce the resulting image on the right. Explain why the contents of the image on the right are distorted. How could the large image be shrunk without these distortions?



[4]

- Q2. (a) Compare how two different edge detectors work and outline their relative advantages and disadvantages. [9]
- (b) Describe an algorithm for performing **connected component labelling**. That is, generate a unique label for each region in the image, and assign each pixel in the image with the appropriate region label. [5]
- (c) List two region descriptors and describe how they can be computed. What transformations are they **invariant** under? [6]

- Q3. (a) (i) The following figures show the intensity values in a very small image I , and also a template T . Calculate the result of performing the **convolution** $C = I \otimes T$.

$$I = \begin{bmatrix} 1 & 3 & 2 & 5 \\ 5 & 0 & 4 & 4 \\ 1 & 1 & 3 & 4 \end{bmatrix} \quad T = \begin{bmatrix} 1 & 2 & 3 \\ 2 & 2 & 2 \\ 2 & 3 & 4 \end{bmatrix} \quad [3]$$

- (ii) How would **template matching** be applied to find the location of faces in the image below?



[3]

- (b) Compare and contrast two different line parameterisations for detection of straight lines using the **Hough Transform**. [6]

- (c) (i) An image consists of a set of identical rows, each containing a sinusoid of constant magnitude and increasing frequency. This image is then filtered in the **frequency domain** with two different filters to produce the images below. Identify the type of each filter.

$$f_1 = \begin{bmatrix} \text{Image with vertical lines of increasing frequency} \end{bmatrix} \quad f_2 = \begin{bmatrix} \text{Image with vertical lines of decreasing frequency} \end{bmatrix} \quad [2]$$

- (ii) An image is shown below that contains motion blur. Describe how – using the **Fourier transform** – the blurring can be reduced.



[6]

- Q4. (a) A step in many 3D recognition systems is to hypothesise a specific pose (i.e. 2D view) of the 3D model. How is the correctness of this hypothesis verified from the image? [2]
- (b) Outline the principals of **geometric hashing** as used for object recognition. [8]
- (c) The **correspondence problem** exists in stereo based 3D reconstruction – i.e. finding corresponding features in the two images. Why does this occur, and how can the problem be solved? [4]
- (d) Compare the **RGB** and **HSI** colour spaces, outlining any advantages and disadvantages. [6]