

**CARDIFF UNIVERSITY
EXAMINATION PAPER**

Academic Year: 2010–2011
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 3 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) Describe the following two schemes for representing images: **run length encoding** and **image pyramids**. Give their advantages and disadvantages. [6]
- (b) A **Gaussian filter** is a **separable** filter which can be used to blur (smooth) an image using **convolution**. Explain what is meant by the terms: Gaussian filter, separable filter and convolution. [6]
- (c) (i) Describe a brute force algorithm for computing the **distance transform**. [1]
- (ii) Describe an algorithm for computing the distance transform more efficiently, and compare its computational efficiency against the algorithm described in part (i). [7]
- Q2. (a) Describe an algorithm to **segment** an image into regions. Give two limitations of this algorithm. [6]
- (b) Imagine that you have an image of the Martian landscape taken by the Mars Rover that has been segmented into labelled regions which need to be analysed and identified using their shape.
- (i) Give three desirable criteria for such shape descriptors. [3]
- (ii) Describe one shape descriptor for regions and say how well it matches the above criteria. [4]
- (c) Consider using the **Hough Transform** to detect circles of arbitrary size and position in an image that has had edge detection applied followed by thresholding.
- (i) What are the parameters in the **accumulator space** for this problem? [2]
- (ii) How does the voting process change if each edge point in the image also contains the edge magnitude and orientation? Explain how this benefits the Hough Transform algorithm. [5]
- Q3. (a) What are the advantages of performing image processing operations in the **frequency (Fourier) domain** as opposed to the spatial domain? [4]
- (b) Consider the **low pass** and the **high pass** filters in the frequency domain. What are the equivalent filters in the spatial domain? Give their names and a numerical example of a 3×3 **kernel** for each. [4]
- (c) Describe how the **linear discriminant analysis** method for pattern classification works. [5]
- (d) Describe a high level model matching scheme for recognising three dimensional objects in two dimensional images. [7]

- Q4. (a) Answer the following questions on **camera calibration**.
- (i) What is the purpose of camera calibration? [2]
 - (ii) List 2 **internal parameters** and 2 **external parameters** used for camera calibration. [2]
 - (iii) Describe and explain the purpose of the **fundamental matrix**. [2]
- (b) Describe the method of **structured lighting** for performing 3D reconstruction, and give three advantages and/or disadvantages. [6]
- (c) Describe how **Gaussian mixture models** (GMMs) can be used to perform skin detection in colour images. Ensure that the detection is performed consistently even if there are lighting variations (both variations in illumination intensity and colour). Give one application of skin detection. [8]