OLLSCOIL NA hÉIREANN MÁ NUAD

THE NATIONAL UNIVERSITY OF IRELAND MAYNOOTH

JANUARY 2014 EXAMINATION

CS410

Computer Vision

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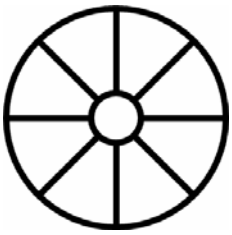
Time allowed: 2 hours

Answer ***three*** questions

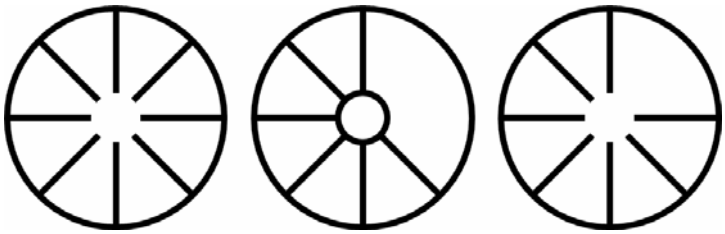
All questions carry equal marks

[25 marks]

1 (a) A manufacturer of drain filters approaches you to design of an industrial inspection system to detect product faults due to the production process. The figure below shows a schematic of a structurally correct filter. Filters come in two sizes, 8cm and 5cm diameters, and consist of two circular pieces connected by 8 spokes.



Two types of fault are occurring in the production process: (i) some subset of spokes are missing, or, (ii) the inner circular section is missing. The vision system must identify and categorise faulty components based on the above fault types. Note that multiple parts or either size may appear in the field of view at any point in time, however you may assume that parts do not touch off of each other.



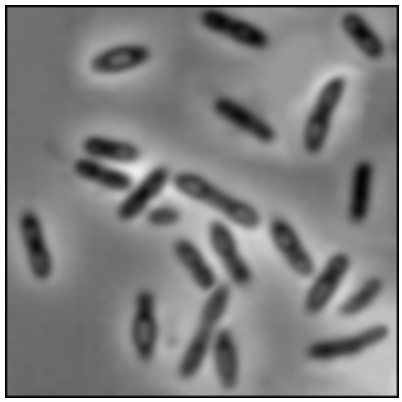
Detail the complete set of processing and analysis steps involved in the implementation of a computer vision system to solve the above problem.

[25 marks]

2 (a) Refer to the problem in Question 1. Now assume that the vision system is to be installed looking directly down on the assembly line and that no part should take up less than 20% of the width or height of the image. Also assume that the camera to be used has a 6.6mm x 6.6mm sensor and is mounted 1 meter above the assembly line. What focal length lens should the system use, given these constraints? If it is not possible to use a lens of the calculated focal length, should a lens of a longer or shorter focal length be chosen? Justify your answer. [9 marks]

(b) The figure below shows a number of micro-organism on a petri-dish. Through **the use of a diagram** illustrate the type of histogram you would expect the image to have. Explain the how the components of the image contribute to the histogram. [8 marks]

In your answer you should provide an argument that the underlying distribution is composed of two Gaussians. In this context, if we wish to segment the micro-organisms from the background using a simple threshold operation, what point in the histogram should we chose as the threshold? Note that you should explain how your choice of threshold results in the *minimum misclassification rate*.



(c) Provide an explanation of how the concept of the axis of least inertia can be used to characterise the orientation of an object in an image. In your answer you should provide expressions of the second moments of an object, and provide an intuitive explanation of the particular aspect of the object's shape that each of the second moments characterises. [8 marks]

[25 marks]

3 (a) Provide an expression for the discrete convolution operation and explain its operation. What is the effect of convolution in the frequency domain, and using this interpretation explain how the operation can be inverted? What are the criteria required to ensure that the operation can be inverted. [10 marks]

(b) The figure below shows a 3x4 neighbourhood of pixels taken from a grayscale image. Demonstrate the complete set of steps involved in detecting the edge pixels in the image using the Sobel filter. Note you should only evaluate the output at the two centre image pixels. [9 marks]

100	101	170	172
101	99	171	170
98	102	168	172

(c) Why does the filter respond at both sides of the edge and why is this an issue? How does the Laplacian operator overcome this problem? [6 marks]

[25 marks]

4 (a) List and explain each of the steps involved in SIFT feature detection and description. [13 marks]

(b) When comparing SIFT features between two images one approach is to simply threshold the Euclidean distance between feature pairs. Why is this approach unreliable and how does the *ratio-test* provide a more robust matching metric? Explain how *mutually consistent matching* can further reduce the false positive matching rate. [12 marks]