Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Monday 19th May 2014
Time: 09:45 - 11:45

Please answer any THREE Questions from the FOUR Questions provided

Use a SEPARATE answer book for each QUESTION

This is a CLOSED book examination

The use of electronic calculators is permitted provided they are not programmable and do not store text

[PTO]
1.

**Figure 1. Left:** A grayscale image of a group of spanners. **Right:** The image histogram for this image.

A third-year project student is trying to design a robot vision system, which will locate individual spanners in an image, so that the robot arm can be used to grasp and lift each spanner. Figure 1 shows an example image, and the image histogram for this image.

a) Suggest a simple method that could be used to segment the set of spanners in this case. You should estimate appropriate numerical values for any parameters that you use, and explain your choice of value. Would your method be of any use in segmenting an individual spanner in this group? Explain your answer.

![Segmented Spanners](image)

**Figure 2.** Example binary images of segmented spanners, showing (from Left to Right), varying orientation, varying size, and simple two-object occlusions.

After changing the experimental set-up, the student manages to obtain binary images of the type shown in Figure 2.

b) Suggest and describe as fully as you can **two** methods which would enable you to count the numbers of spanners, and classify them by size and orientation. In each case, you should describe in detail the steps involved, and explain how they achieve their results. You should make clear whether each method would also succeed in the occluded case. You may assume that the approximate possible sizes of the spanners are known, but **not** their possible orientations.

![Segmented Spanners](image)

**End of Question 1**
2.

A third-year project student is doing a medical image analysis project, and is studying the shape variation of a particular brain structure (Figure 3). She is given a suitable dataset of 2D images showing the structure in question, along with whatever expert annotation of these images that she requires. She intends to build a statistical shape model (SSM) using this information.

a) Explain briefly what annotation she would require in order to build a statistical shape model from this data, and how she would use that annotation in order to generate a representation of a shape suitable for use in building an SSM. What problems with annotation might she have if she decided to use 3D rather than 2D data?

[4 marks]

b) Describe in detail the steps involved in constructing a statistical shape model from this data.

[8 marks]

c) The Active Shape Model (ASM) is one way of matching such a shape model to a new image. Describe how to build the other components required by an ASM.

[4 marks]

d) Another student has proposed to construct an Active Contour Model (ACM) to find the same structure. Which of these two approaches, the ACM or the ASM, do you think would be the most successful at this task? Explain your answer.

[4 marks]

Figure 3. Diagram showing the ventricles in a human brain. The ventricles are fluid-filled cavities within the brain, that appear dark in this particular type of image.

End of Question 2
3.

a) Briefly describe the main steps of
   i) Mean-shift algorithm [2 marks]

b) What are the advantages and disadvantages of
   i) K-means clustering algorithm [4 marks]
   ii) EM clustering algorithm [4 marks]
   iii) Mean-shift clustering algorithm [4 marks]

c) Consider an image consisting of two sets of points. One is a set of points distributed roughly uniformly on a circle of radius \( r \) centred at point \( C_1 \), which is near the centre of the image. The other set of points is distributed on a circle of radius \( 2r \), which is centred at point \( C_2 \), which is located inside the other circle. Assume the points in each set are distributed densely enough so that the distances between points on the same circle are smaller than the distances between points on different circles (Figure 4). Describe what segmentation the k-means algorithm would produce for this example, and briefly explain why. [6 marks]

![Figure 4](image-url)
4. In Computer Vision it is often useful to identify *interest points* in an image.

a) Explain what an “*interest point*” in an image means. [2 marks]

b) Explain what a “*corner detector*” is. What is the main difference in the information provided by edge and corner features? [4 marks]

c) Describe a method that could be applied to detect interest points in an image. You may choose to describe any *interest point* detector but you need to explain how the operator is applied to the image and how interest points are identified. [4 marks]

d) Describe how interest points can be used in each of

i) Correspondence matching for stereo reconstruction [5 marks]
ii) Object detection [5 marks]

*End of Question 4*

END OF EXAMINATION