

Two hours

**UNIVERSITY OF MANCHESTER  
SCHOOL OF COMPUTER SCIENCE**

Computer Vision

Date: Tuesday 30th May 2017

Time: 09:45 - 11:45

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**Please answer any THREE Questions from the FOUR Questions provided**

**Use a SEPARATE answer book for each QUESTION**

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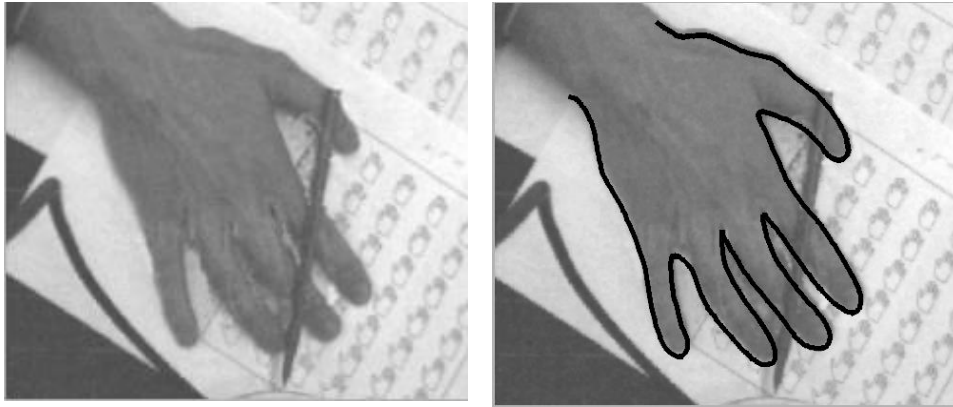
This is a CLOSED book examination

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

**[PTO]**

1.

A COMP37212 student is working with a set of images of a human hand resting on a table covered with papers. In some of the images (see the example in **Figure 1**), there is a pen partly obscuring the hand.



**Figure 1:** **Left:** An example hand image, with a hand and a pen.  
**Right:** An annotated curve showing the outline of the hand.

After some thought, she decides that it may be useful to implement the Hough Transform for lines to help in finding the pen.

- a) Explain the principle of the Hough Transform for lines. [5 marks]
- b) What steps would she need to take in pre-processing such images before applying the Hough Transform? How might she use the output of the Hough Transform to identify and locate a pen? [3 marks]

She then annotates all the images in her dataset with curves showing the hand outlines, and also adds **suitable** landmark points. The landmark points are then used to construct a statistical shape model (SSM) of the hands.

- c) Describe *in detail* the steps involved in constructing such a statistical shape model. [8 marks]

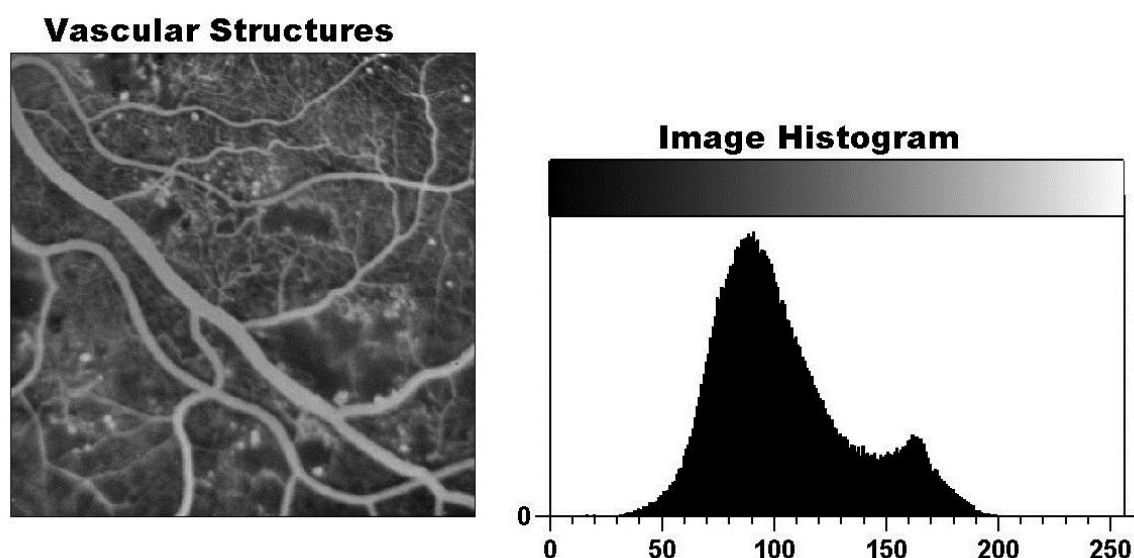
She then uses this statistical shape model in the construction of an Active Shape Model (ASM), in order to try and locate the hand in such images. A fellow student instead constructs an Active Contour Model (ACM) to try and perform the same task.

- d) Use a simple sketch to show the likely result given by the ASM and the ACM. Explain briefly why each gives the result that it does. [4 marks]

*End of Question 1*

2.

A COMP37212 student is working on the image shown at the left of **Figure 2** below, which shows blood vessels in a human retina. The student computes the image histogram for this image, which is shown at the right of **Figure 2**.

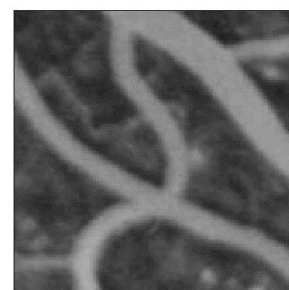


**Figure 2. Left:** The grayscale (0-255) image extracted from a retinogram, showing details of the vessels. **Right:** The image histogram for this image.

Describe a detailed strategy for:

- a) Locating the major vessels in the image [8 marks]
- b) Tracing the paths of each vessel, and the junctions between vessels. [8 marks]
- c) Measuring the distances along the vessels between junctions, and measuring the width of the vessels at any specified point. [4 marks]

At each stage, you should provide a detailed description of the processes you would use, and explain why they are suitable for the task. You should also explain how the values of any necessary parameters might be determined. By means of suitable diagrams or otherwise, you should describe the output you would expect at each stage of the process. You may find it useful to refer to **Figure 3** when sketching the expected output. You should also indicate what problems you might encounter in applying your suggested techniques, and how these might be overcome.



**Figure 3.** A close-up view of part of the image from Figure 2

*End of Question 2*

3.

Consider the data in figure 4.

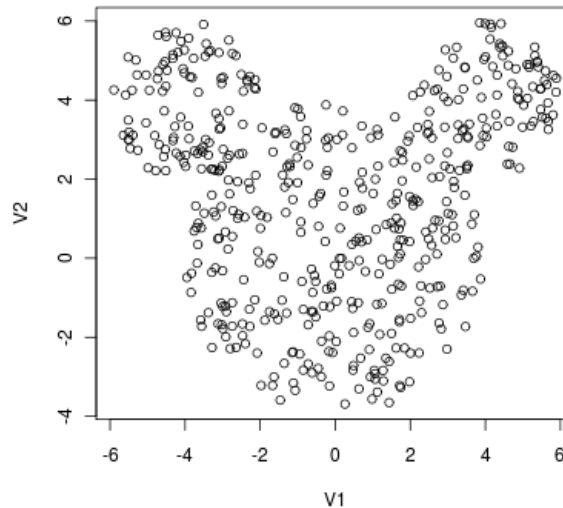


Figure 4

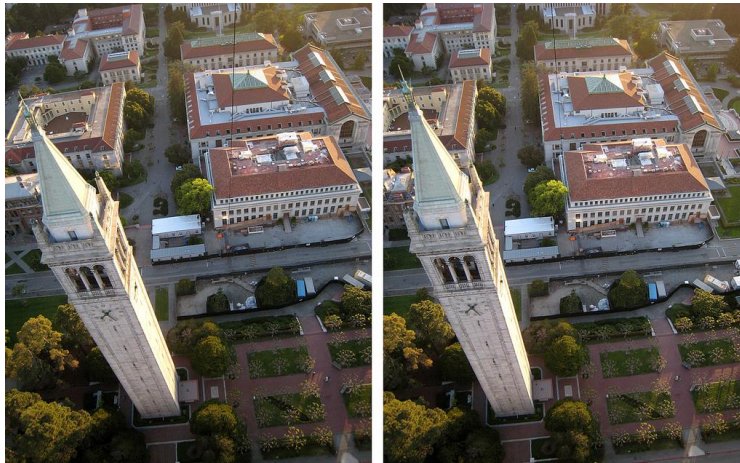
- a) What do you expect to happen if we run the K-means algorithm with *three* clusters on this data set? Explain why you expect this to happen. [6 marks]
- b) Propose and *describe* an alternative algorithm to cluster the data in figure 4. Justify your choice. [8 marks]
- c) What are the *advantages* of your proposed algorithm compared to the K-means algorithm? [6 marks]

*End of Question 3*

4.

Figure 5 shows a pair of stereo images that have been captured using a pair of calibrated cameras.

- a) Define **disparity** in stereo vision. [2 marks]
- b) Describe a method for **detecting interest points** in an image. [6 marks]
- c) Is the **Harris corner** detector a **linear** filter? Argue why or why not. [2 marks]
- d) Explain how you could use the pair of images in figure 5 to calculate the **distances from the camera** of the surface features that appear in the scene.



**Figure 5**

In your answer you need to consider all steps in the process, from images to depth values. You also need to give a diagram to illustrate your answer.

[10 marks]

*End of Question 4*

**END OF EXAMINATION**