Two hours

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Computer Vision

Date: Tuesday 3rd June 2008

Time: 14:00 – 16:00

Please answer any THREE Questions from the FIVE questions provided

Use a SEPARATE answer book for each Section.

This is a CLOSED book examination

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

1. The images below (figure 1) show examples of the appearance of finger bones cropped from radiographs of hands. The top row shows the original image, the images in the bottom row show the same images after noise reduction and contrast enhancement.

a) Noise reduction may be achieved by either linear or non-linear methods. Describe an example of each. (6 marks)

b) Which method do you think was used to process the images above? Explain the reasons for your choice. (2 marks)

c) One approach to locating the boundary of the large bone in each image is to use an Active Contour Model. An Active Contour Model involves optimizing a combination of two energy terms – what is the purpose of the two terms? (2 marks)

d) Suppose that we represent the closed contour using a numbered set of points, \((x_i, y_i)\) \((i=1..n)\). Give an example of possible equations for each of the two energy terms in terms of the point positions and information sampled from the image. (3 marks for each term)

e) Suggest a method of initializing the active contour model so that the optimization is likely to be successful. (2 marks)

f) What problems may arise when using an Active Contour Model on the images above? (2 marks)

Figure 1
2. Suppose that we are given a set of images, together with a closed curve on each one defining the outline of a bone, such as those shown in figure 2, below. The closed curve is provided as a dense list of pixel co-ordinates \((x_i, y_i)\) for each example, but since the curves are different lengths in each image, there are different numbers of points on each closed curve.

![Figure 2](image)

We wish to construct a statistical shape model from the data. However, this requires us to find the same number of ‘landmark’ points on each curve.

a) What does such a set of landmarks define? (2 marks)

b) Describe in detail a method for selecting such points which would be suitable for constructing a statistical shape model. (6 marks)

c) Given sets of landmark points on each shape, explain how to align each set to a common co-ordinate frame before building a statistical shape model, and why it is necessary. (4 marks)

d) Given a set of aligned shapes, we can construct a statistical shape model. One method of matching such a model to a new image is the Active Shape Model (ASM) algorithm. Describe how to build the other components required by an ASM. (4 marks)

e) Describe in outline the two steps involved in a single iteration of the ASM matching algorithm. (4 marks)
3. In computer vision it is often useful to identify “interest points” in an image. Examples of “interest operators” that locate such points are the Moravec or Harris detectors.

a) Explain, in general terms what is meant by an “interest point” in an image. (2 marks)

b) Describe two different methods that could be applied in detecting interest points. (You may choose to describe the Harris or Moravec operators, but there are others). In each case describe how the operator is applied to the image and how the interest points are identified. (8 marks)

c) Describe how interest operators could be used in each of

i) Correspondence matching for stereo reconstruction. (5 marks)

ii) Object detection. (5 marks)
4. Figure 3 shows a still image from a surveillance video of a road junction. The junction is busy, with vehicles passing through constantly. As a vision engineer you are asked to devise a vision system to gather information about traffic flow through the junction. Your system will track the passage of vehicles across the junction, identifying where they enter, where they leave, and their average speed through the junction.

You consider three different approaches to assessing the motion of vehicles:

a) Optical Flow
b) Tracking of individual vehicles
c) Change detection

In each case describe in outline how motion is calculated and evaluate whether the method would be useful for:

i) Identifying vehicles entering the junction,
ii) Identifying the trajectory of vehicles through the junction,
iii) Measuring the velocity of vehicles,

giving reasons for your evaluation.

[Mark distribution - outline of methods: (a) 5 marks, (b) 5 marks, (c) 1 mark; Evaluation: 1 mark for each of (i), (ii), (iii) in each case, i.e 3 marks in each of parts (a), (b), (c)]

(20 marks)
5. Figure 4a shows an example of a microscope image showing stained chromosomes. With this form of staining the different chromosomes in a cell can be classified into one of seven groups on the basis of the chromosome’s size and the position of the crossing point (which could be characterised by the ratio $l_1/l_2$ as indicated on the schematic diagram, figure 4b). Assuming this is a typical image, describe a strategy for:

a) locating each chromosome on the image. (5 marks)

b) making the measurements necessary to identify the chromosome. (8 marks)

c) carrying out the classification. (7 marks)

At each stage you should provide a detailed description of the processes that you would use.