Medical Scientific Computing D8 C333 2000

Answer any THREE questions.

Marks for each part of each question are indicated in square brackets.

Calculators may be used.

(Algorithms may be written in any suitable language.)

1. a What is the effect of (so-called) aliasing when digitising data?

[5 Marks]

b If you want to collect a series of cardiac angiograms, where the resolution is 0.1mm, the diameter of the field of view is 20cm and you require 16 frames per heart beat, what is the overall data rate? Indicate the various assumptions you have made.

[5 Marks]

c Describe how you would identify and quantify the extent of a blockage (stenosis) in an artery, and suggest also how this measurement could be improved if you recorded images from different angles.

[8 Marks]

d How could you identify a specific section of an arterial tree observed from two different angles at the same time, and describe some of the sources of error that you might encounter?

[7 Marks]

[Turn Over]

2. a If you had a 3-d dataset, being a series of parallel slices through an organ, how would you construct a new 2-d image (slice), at some arbitrary angle in 3-d, from the 3-d dataset?

[6 Marks]

b What is a deformable contour (snake) and describe how you could use it, in a single slice through an organ, to outline that organ.

[6 Marks]

c While the total volume of an organ can be estimated by counting voxels with respect to a threshold, or by summing the areas within a set of deformable contours, indicate why these might give different values depending on the type of image being analysed.

[6 Marks]

d Describe what is the medial axis of an object in both 2 and 3 dimensions, and indicate, computationally how you might find it.

[7 Marks]

3. a Define a projection, as used in acquiring data in a CT scanner.

[4 Marks]

b Describe in reasonable detail an iterative algorithm for performing tomographic reconstruction of for example x-ray CT data, describing in particular the rules for stopping the iterative procedure.

[6 Marks]

c Estimate the relative computational time that might be required to reconstruct an image using such an iterative algorithm with that needed to solve the complete set of simultaneous equations relating the values of the projections to the value of the pixels in the reconstructed image.

[8 Marks]

d Since, in many cases, the projections acquired do not correspond exactly to the sums of discrete points along projection rays (line integrals), how may this be taken into account, and what is the effect with respect to computational time?

[7 Marks]

[Continued]

4. a What is the correct interpolation that should be used to reconstruct continuous data from a set of digital samples? Estimate the error that might occur if you used linear interpolation.

[5 Marks]

b How can you select a particular slice through an object in Magnetic Resonance imaging?

[6 Marks]

c Since you have only a limited time to select such a slice, estimate what happens to the slice profile (thickness of the slice) as a result.

[8 Marks]

d What is the partial volume effect? What is the influence of this effect in clinical images, as in estimating the ratio of brain white matter to grey matter ratio? You may choose your own example.

[6 Marks]

5. a Describe an algorithm for computing the frequency of occurrence (1-d) histogram of pixel values in an image

[5 Marks]

b Show how this can be extended to generate a 2 dimensional histogram (the co-occurrence matrix) for a pair of images, or for some shift in a single image.

[5 Marks]

c Indicate some measures of uniformity of this 2-d histogram.

[4 Marks]

d How can minimising such a measure of uniformity be used to attempt to register two images, and describe in reasonable detail an algorithm that could be used for such minimisation?

[6 Marks]

e How (and to what extent) can such an algorithm be accelerated by sampling at different resolutions during this minimisation process

[5 Marks]

[Turn Over]

6. a Describe, with the aid of a diagram, the relationships between the different types of data (entities) that might be found in a Picture Archiving and Communication System (PACS) and a Hospital Information System (HIS).

[6 Marks]

b Describe, again using a diagram, how different devices may be connected together, such as archives, workstations, data acquisition devices such as CT scanners. Give estimates of the data rates required for the different sections of the network you have described.

[6 Marks]

c When data needs to be transferred between different parts of the network, various events occur or need to have occurred previously. Describe such a dynamic model for the case of reporting results for previously acquired images.

[7 Marks]

d Suppose that we wished to transfer a sequence of 128 CT slices of size 512x512 each over a busy 10Mbit link where 90% of the bandwidth is already occupied, estimate the time that this would take, and suggest methods for improving this.

[6 Marks]

[END OF PAPER]