UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2004

BEng Honours Degree in Computing Part III
MSc in Computing Science
MSc in Computing for Industry
BEng Honours Degree in Information Systems Engineering Part III
MEng Honours Degree in Information Systems Engineering Part III
for Internal Students of the Imperial College of Science, Technology and Medicine

This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute

PAPER C346=I3.12

MULTIMEDIA SYSTEMS

Wednesday 28 April 2004, 10:00
Duration: 120 minutes

Answer THREE questions

Paper contains 4 questions
Calculators required

Section A *(Use a separate answer book for this Section)*

1a How is the intensity of a sound related to its perceived loudness by a human listener? Using an appropriate diagram, briefly describe the technique of *companding* and how it exploits this relationship to reduce the bandwidth required to send audio signals.

b Briefly describe how block matching can be used to estimate motion vectors between video frames. Explain *one* example of a local search strategy, using diagrams as appropriate. What assumption is made by such strategies and why does that make them sub-optimal?

c A text file contains only the characters *a*, *b*, and *c*, with frequencies P(*a*) = 0.3, P(*b*) = 0.6, and P(*c*) = 0.1 respectively.

i) Draw a Huffman tree for this text and list the corresponding codes. When joining two nodes, place the lower-frequency node on the right.

ii) Calculate the average code length per character and the compression ratio achieved versus an 8-bit ASCII encoding.

d Suppose the characters in part b) are correlated such that every *a* or *c* is always immediately followed by a *b*, but *b*'s can be independently followed by any character. Now consider the file in terms of character pairs – that is, *aa*, *ab*, *ac*, *ba*, *bb*, etc.

i) Draw a Huffman tree for this text using character pairs, *ignoring* the pairs with zero frequency, and list the corresponding codes. When joining two nodes, place the lower-frequency node on the right.

ii) Calculate the average code length *per character* and the compression ratio achieved versus an 8-bit ASCII encoding.

iii) Explain why this method achieves greater compression than in part c).

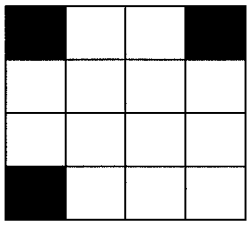
The four parts carry, respectively, 20%, 30%, 15%, and 35% of the marks.

2a Explain why the JPEG compression algorithm uses a chrominance-luminance colour model instead of an RGB colour model.

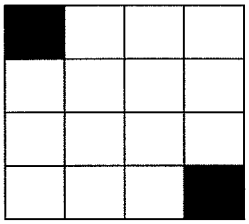
b List the processing steps involved in IFS fractal compression using Jacquin's approach, and explain its strengths and weaknesses. What effects do the initial choice of seed image have on the decompression process?

c Consider the following 4x4 blocks of DCT coefficients. Sketch the corresponding 4x4 images.

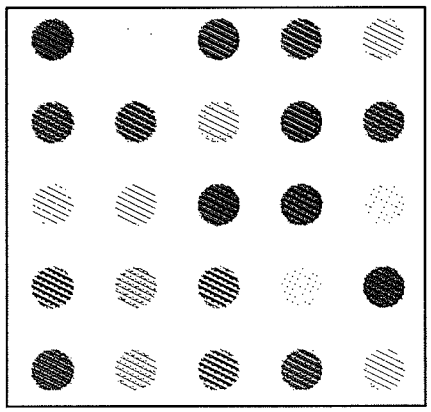
i)



ii)



d The Lyle art gallery is in the process of creating a digital image library of its paintings collection and has asked you to design the image storage technique. A major part of the collection are the well-known spot paintings by Damien Wurst, which consist of sharp monochromatic spots on a white background, as shown in the following figure. (Although the figure is black and white, the actual spots are in colour.) It is important for the images to be as accurate as possible with respect to the original pictures.



i) Explain why it is *inappropriate* to adopt JPEG image compression for this purpose.

ii) Propose a compression technique that will provide a high image compression ratio while retaining high fidelity to the original pictures. Explain all the necessary steps involved and justify how your method achieves good compression.

The four parts carry, respectively, 20%, 20%, 20%, and 40% of the marks.

Section B *(Use a separate answer book for this Section)*

3a i) State the aims of the MPEG-1 and MPEG-2 standards.

ii) Outline how these requirements are met in the two standards and list the additional features of MPEG-2.

iii) Explain how the MPEG-2 Transport stream supports multiple audio/video streams.

b A television company wishes to augment its programs with web pages transmitted over unused lines in the vertical blanking interval. What data rate would you expect to be achieved using six lines per field? Do you think the throughput would be sufficient for the requirement? Justify your answers.

c i) "Video on Demand" is an overall term for a wide set of services. Differentiate between the possible levels of provision, indicating the resources that each requires.

Describe the kind of service you would expect to be available from

ii) A cable TV company

iii) A content provider accessed via ADSL over a standard telephone line.

Include how the nature of the network in each case affects the service offered.

The three parts carry, respectively, 30%, 30%, 40% of the marks.

4a i) Compact Disk was originally intended for digital audio, but is now also used on computers for storage, including multimedia data. Explain how the hardware characteristics of CDs and their drives affect their suitability for this new role.

ii) Describe why the video CD (White Book) standard was considered unsuitable by the Hollywood studios for distribution of their films to the home market. List their requirements and how they are addressed by DVD.

iii) Explain the difference between frame rate and refresh rate. Describe a situation in which they are related and another in which they are not.

b For networked digital video, give an example of

i) A symmetric application

ii) An asymmetric application

Explain the nature of each type of application and include its resource requirements.

c i) With the aid of sketches, illustrate the difference between 4:1:1 and 4:2:0 chroma subsampling. What is the compression ratio achieved in each case?

ii) Explain how the CIF video standard is derived from ITU-R Recommendation 601 for digital video. Why does CIF for video conferencing and video telephony via H.261 and H.263 use 4:2:0 rather than 4:1:1?

iii) Suggest an appropriate way of generating CIF video for transmission via H.261 from a PAL video camera. How might you improve your method for offline (non-realtime) generation of CIF video from pre-recorded PAL video?

The three parts carry, respectively, 30%,30%, 40% of the marks.