CARDIFF CARDIFF UNIVERSITY
EXAMINATION PAPER

SOLUTIONS

Academic Year:	2001-2002
Examination Period:	Autumn 2001
Examination Paper Number:	CM0340
Examination Paper Title:	Multimedia
Duration:	2 hours

Do not turn this page over until instructed to do so by the Senior Invigilator.

Structure of Examination Paper:
There are three pages.
There are four questions in total.

There are no appendices.

The maximum mark for the examination paper is 100% and the mark obtainable for a question or part of a question is shown in brackets alongside the question.

Students to be provided with:
The following items of stationery are to be provided:
One answer book.

Instructions to Students:
Answer THREE questions.

The use of translation dictionaries between English or Welsh and a foreign language bearing an appropriate departmental stamp is permitted in this examination.

1. *(a) Give a definition of multimedia and a multimedia system.*

Multimedia is the field concerned with the computer-controlled integration of text, graphics, drawings, still and moving images (Video), animation, audio, and any other media where every type of information can be represented, stored, transmitted and processed digitally.

A **Multimedia System** is a system capable of processing multimedia data and applications.

2 Marks - BOOKWORK

(b) What are the key distinctions between multimedia data and more conventional types of media?

Multimedia systems deal with the generation, manipulation, storage, presentation, and communication of information in digital form.

The data may be in a variety of formats: text, graphics, images, audio, video.

A majority of this data is large and the different media may need synchronisation -- the data may have **temporal** relationships as an integral property.

Some media is **time independent** or **static** or **discrete** media: normal data, text, single images, graphics are examples.

Video, animation and audio are examples of **continuous** media

4 Marks Bookwork

(c) What key issues or problems does a multimedia system have to deal with when handling multimedia data?

A Multimedia system has four basic characteristics:

- Multimedia systems must be computer controlled.
- Multimedia systems are integrated.
- The information they handle must be represented digitally.
- The interface to the final presentation of media is usually interactive.

Multimedia systems may have to render a variety of media at the same instant -- a distinction from normal applications. There is a temporal relationship between many forms of media (e.g. Video and Audio. There 2 are forms of problems here

- Sequencing within the media -- playing frames in correct order/time frame in video
- Synchronisation -- inter-media scheduling (e.g. Video and Audio). Lip synchronisation is clearly important for humans to watch playback of video and audio and even animation and audio. Ever tried watching an out of (lip) sync film for a long time?

The key issues multimedia systems need to deal with here are:

- How to represent and store temporal information.
- How to strictly maintain the temporal relationships on play back/retrieval
- What process are involved in the above.

Data has to represented digitally so many initial source of data needs to be digitise -- translated from analog source to digital representation. The will involve scanning (graphics, still images), sampling (audio/video) although digital cameras now exist for direct scene to digital capture of images and video.

The data is large several Mb easily for audio and video -- therefore storage, transfer (bandwidth) and processing overheads are high. Data compression techniques very common.

7 Marks BOOK WORK

(d) An analog signal has bandwidth that ranges from 15Hz to 10 KHz. What is the rate of sampler and the bandwidth of bandlimiting filter required if:

(i) the signal is to be stored within computer memory.

Nyquist Sample Theorem rate says that sampling must be **at least twice** the highest frequency component of signal or transmission channel

Highest frequency is 10 KHz so
Sampling rate = 20 KHz or 20,000 sample per second. **1 Mark**

Bandwidth of bandlimiting filter = 0 – 10 KHZ **2 Marks**

(ii) the signal is to be transmitted over a network which has a bandwidth from 200Hz to 3.4 KHz.

Channel has lower rate than max in signal so must choose this a limiting high frequency so

Sampling rate = 6.8 KHz or 6,800 sample per second. **2 Marks**

Bandwidth of bandlimiting filter = 0 – 3.4 KHZ **2 Marks**

7 Marks TOTAL: ALL UNSEEN

(e) Assuming that each signal is sampled at 8bits per sample what is the difference in the quantisation noise and signal to noise ratio expected for the transmission of the signals in (i) and (ii).

Quantisation noise = $V_{max}/2^{n-1}$

SNR = 20 log ($V_{maxa}l/V_{min}$)

So for (i) Quantisation noise = 78.125
SNR = 20 log (10,000/15) = 56.48 Db

3 Marks

And (ii) Quantisation noise = 26.56
SNR = 20 log (3,400/15) = 47.11 Db

4 Marks

7 Marks TOTAL: ALL UNSEEN

2. (a) Why is data compression necessary for Multimedia activities?

Audio and Video and Images take up too large memory,disk space or bandwidth uncompressed.

3 Marks BookWork

(b) What is the distinction between lossless and lossy compression? What broad types of multimedia data are each most suited to?

Lossless Compression
-- where data is compressed and can be reconstituted (uncompressed) without loss of detail or information. These are referred to as bit-preserving or reversible compression systems also.

Lossy Compression
-- where the aim is to obtain the best possible fidelity for a given bit-rate or minimizing the bit-rate to achieve a given fidelity measure. Video and audio compression techniques are most suited to this form of compression.

Types sutability

Lossless
Computer data fles (compression)
Graphcs and graphical images lossless (GIF/LZW)

Lossy
Audio MP3
Photographic images (JPEG)
Video (Mpeg)

5 Marks Bookwork

(c) Briefly explain the compression techniques of zero length suppression and run length encoding. Give one example of a real world application of each compression technique.

Simple Repetition Suppresion

Simplest Suppression of zero's in a --- ***Zero Length Supression***

If in a sequence a series on *n* successive tokens appears we can replace these with a token and a count number of occurences. We usually need to have a special *code* to denote when the repated token appears

For Example

89400000000000000000000000000000000

we can replace with

894f32

where f is the code for zero.

Example:

- Silence in audio data, Pauses in conversation
- Bitmaps
- Blanks in text or program source files
- Backgrounds in images

Run-length Encoding

This encoding method is frequently applied to images (or pixels in a scan line). It is a small compression component used in JPEG compression.

In this instance, sequences of image elements (X_1,X_2, …X_n)are mapped to pairs (c_1,l_1, c_2,l_2…,(c_n,l_n) where c_i represent image intensity or colour and l_i the length of the ith run of pixels (Not dissimilar to zero length supression above).

For example:

Original Sequence:

111122233333311112222

can be encoded as:

(1,4),(2,3),(3,6),(1,4),(2,4)

The savings are dependent on the data. In the worst case (Random Noise) encoding is more heavy than original file: 2*integer rather 1* integer if data is represented as integers.

Examples

- Simple audo
- graphics
- Images

7 Marks Bookwork

(d) Show how you would encode the following token stream using zero length suppression and run length encoding:

ABC000AAB00000000DEFAB00000

Total length of token stream = 27

Zero Length Suppresson Code

ABC<u>f</u>3AAB<u>f</u>8DEFAB<u>f</u>5

Number of tokens 17 where <u>f</u> is code for 0

Run Length Encoding

A1B1C103A2B108D1E1F1A1B105

Number of tokens 26

(i) What is the compression ratio for each method when applied to the above token stream?

Total length of token stream = 27

Zero Length Suppresson Code

ABC<u>f</u>3AAB<u>f</u>7DEFAB<u>f</u>5

Number of tokens 17 where <u>f</u> is code for 0

Run Length Encoding

A1B1C103A2B107D1E1F1A1B105

Number of tokens 26

Compresson ratios:

Zero length Supresson = 17/27

Run Length Encoding = 26/27

3 Marks each for correct encoding
2 Mark for each ratio
10 Marks Total

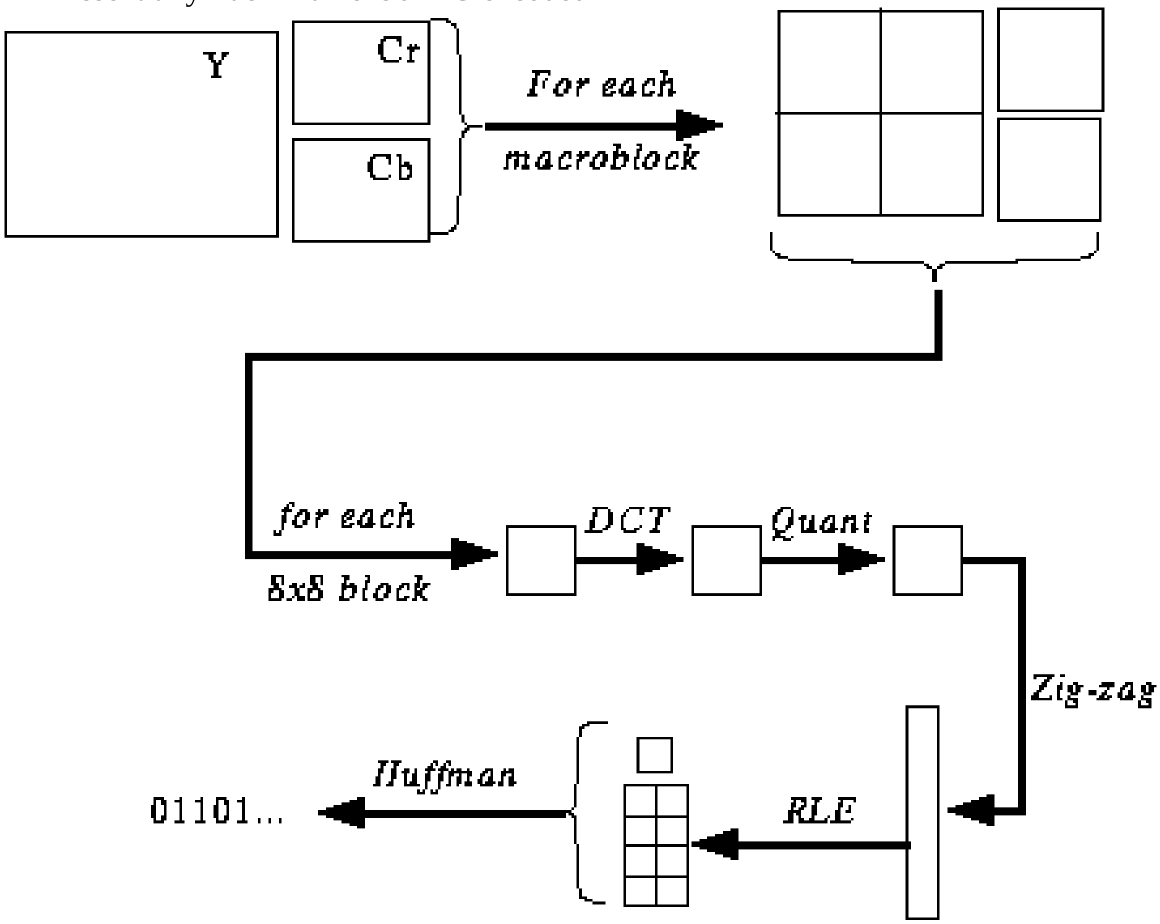
(ii) Explain why one has a better compression ratio than the other. What properties of the data lead to this result?

Data has only one repeated token the 0. So coding is wasted on rapidly changing remainder of data in run length encoding where every token frequency count needs recording.   2 Marks

12 Marks for all of PART (d) ALL WORK UNSEEN

3. (a) *Briefly outline the basic principles of Inter-Frame Coding in Video Compression.*

Essentially Each Frame is JPEG encoded



- Macroblocks are 16x16 pixel areas on Y plane of original image.

  A ***macroblock*** usually consists of 4 Y blocks, 1 Cr block, and 1 Cb block.

- Quantization is by constant value for all DCT coefficients (i.e., no quantization table as in JPEG).

The Macroblock is coded as follows:

Addr	Type	Quant	Vector	CBP	b0	b1	...	b5

- Many macroblocks will be exact matches (or close enough). So send address of each block in image -> *Addr*

- Sometimes no good match can be found, so send INTRA block -> *Type*
- Will want to vary the quantization to fine tune compression, so send quantization value -> *Quant*
- Motion vector -> *vector*
- Some blocks in macroblock will match well, others match poorly. So send bitmask indicating which blocks are present (Coded Block Pattern, or *CBP*).
- Send the blocks (4 Y, 1 Cr, 1 Cb) as in JPEG.

8 Marks BOOKWORK

(b) *What is the key difference between I-Frames, P-Frames and B-Frames? Why are I-frames inserted into the compressed output stream relatively frequently?*

I-Frame --- Basic Refernce FRAME for each Group of picture. Essentially a JPEG Compressed image.

P-Frame --- Coded *forward* Difference frame w.r.t last I or P frame

B-Frame --- Coded *backward* Difference frame w.r.t last I or P frame

I-frame Needed regularly as differences cannot cope with drift too far from rerence frame. If not present regularly poor image quality results.

6 Marks BOOKWORK

(c) *A multimedia presentation must be delivered over a network at a rate of 1.5 Mbits per second. The presentation consists of digitized audio and video. The audio has an average bit rate of 300 Kbits per second. The digitised video is in PAL format is to be compressed using the MPEG-1 standard. Assuming a frame sequence of:*

IBBPBBPBBPBBI…..

and average compression ratios of 10:1 and 20:1 for the I-frame and P-frame what is the compression ratio required for the B-frame to ensure the desired delivery rate?

You may assume that for PAL the luminance Signal is sampled at the spatial resolution of 352x288 and that the two chrominance signals are sampled at half this resolution. The refresh rate for PAL is 25Hz. You should also allow 15% overheads for the multiplexing and packetisation of the MPEG-1 video.

Desired Rate = 1.5 Mbits/Sec

Desired video rate = Rate – audio rate
= 1.5 – 0.3 = 1.2 Mbits/Sec

Physical rate = Video Rate less Headroom
= 1.2 / 1.15 = 1.044 Mbits/Sec

Each Group has 12 Frame: 1 I, 8 B and 3 P frames

So average frame rate = (0.1 + 3*0.05 + 8x)/12 = (0.25 + 8x)/12

Each frame has: 352*288*8 + 2*(176*144*8) bits (uncompressed) = 1,216,512 bits

So average Compressed bits per frame (average over 12 frames GoP) = 1216512*(0.25 + 8x)/12

Therefore Bits per second at 25 Frames per Sec rate= 25*1216512*(0.25 + 8x)/12

We require:

25*1216512*(0.25 + 8x)/12 = 1044000
2534400*(0.25 + 8x) = 1044000
(0.25 + 8x) = 0.412
8x = 0.16
x = 0.02

Or the compression ratio **is 50:1 for the B-FRAME**

13 MARKS UNSEEN

4. (a) *What key features of Quicktime have led to its adoption and acceptance as an international multimedia format?*

QuickTime is the most widely used cross-platform multimedia technology available today. QuickTime developed out of a multimedia extension for Apple's Macintosh(proprietry) System 7 operating system. It is now an international standard for multimedia interchange and is avalailbe for many platforms and as Web browser plug ins.

The following main features are:

- Versatile support for web-based media
- Sophisticated playback capabilities
- Easy content authoring and editing
- QuickTime is an ***open standard*** -- it embraces other standards and incorporates them into its environment. It supports almost every major Multimedia file format

4 Marks – BOOKWORK

(b) Briefly outline the Quicktime Architecture and its key components.

The QuickTime Architecture:

QuickTime comprises two managers: the Movie Toolbox and the Image Compression Manager. QuickTime also relies on the Component Manager, as well as a set of predefined components. Figure below shows the relationships of these managers and an application that is playing a movie.

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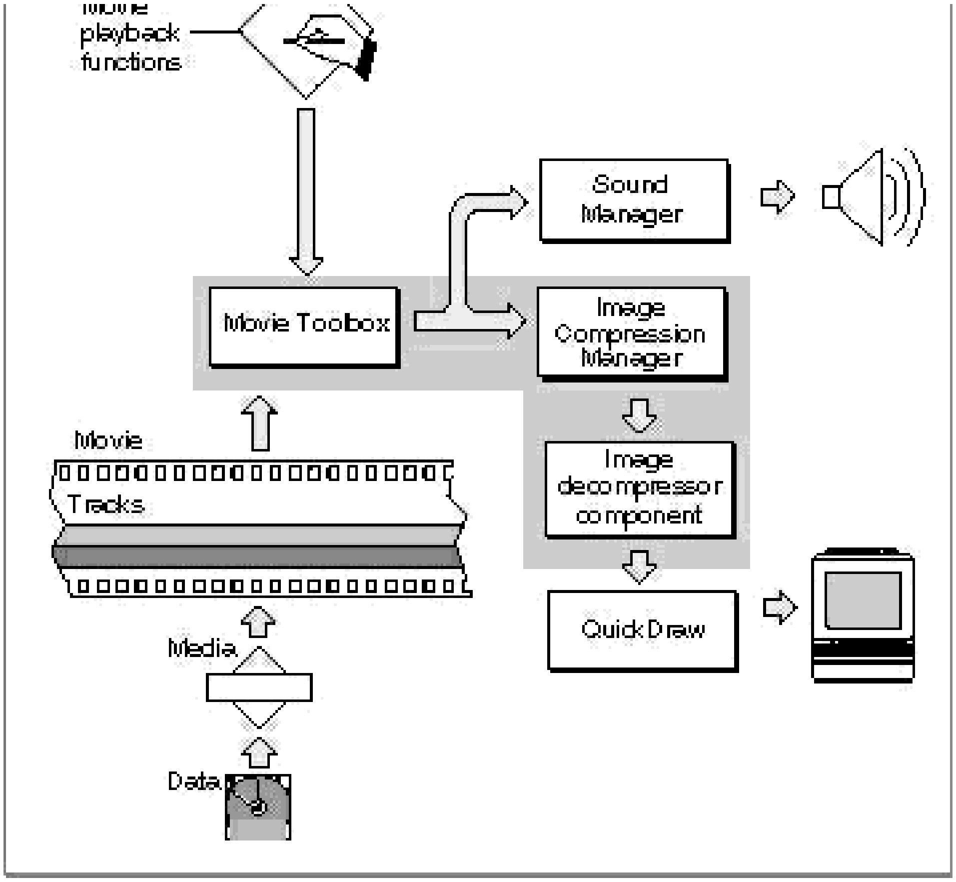

The Movie Toolbox
-- Your application gains access to the capabilities of QuickTime by calling functions in the Movie Toolbox. The Movie Toolbox allows you to store, retrieve, and manipulate time-based data that is stored in QuickTime movies. A single movie may contain several types of data. For example, a movie that contains video information might include both video data and the sound data that accompanies the video.

The Movie Toolbox also provides functions for editing movies. For example, there are editing functions for shortening a movie by removing portions of the video and sound tracks, and there are functions for extending it with the addition of new data from other QuickTime movies.

The Movie Toolbox is described in the chapter "Movie Toolbox" later in this book. That chapter includes code samples that show how to play movies.

The Image Compression Manager
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The Image Compression Manager comprises a set of functions that compress and decompress images or sequences of graphic images.

The Image Compression Manager provides a device-independent and driver-independent means of compressing and decompressing images and sequences of images. It also contains a simple interface for implementing software and hardware image-compression algorithms. It provides system integration functions for storing compressed images as part of PICT files, and it offers the ability to automatically decompress compressed PICT files on any QuickTime-capable Macintosh computer.

In most cases, applications use the Image Compression Manager indirectly, by calling Movie Toolbox functions or by displaying a compressed picture. However, if your application compresses images or makes movies with compressed images, you will call Image Compression Manager functions.

The Image Compression Manager is described in the chapter "Image Compression Manager" later in this book. This chapter also includes code samples that show how to compress images or make movies with compressed images.

The Component Manager
--

Applications gain access to components by calling the Component Manager. The Component Manager allows you to define and register types of components and communicate with components using a standard interface. A component is a code resource that is registered by the Component Manager. The component's code can be stored in a systemwide resource or in a resource that is local to a particular application.

> Once an application has connected to a component, it calls that component directly. If you create your own component class, you define the function-level interface for the component type that you have defined, and all components of that type must support the interface and adhere to those definitions. In this manner, an application can freely choose among components of a given type with absolute confidence that each will work.

QuickTime Components :

- movie controller components, which allow applications to play movies using a standard user interface standard image compression dialog components, which allow the user to specify the parameters for a compression operation by supplying a dialog box or a similar mechanism
- image compressor components, which compress and decompress image data sequence grabber components, which allow applications to preview and record video and sound data as QuickTime movies video digitizer components, which allow applications to control video digitization by an external device
- media data-exchange components, which allow applications to move various types of data in and out of a QuickTime movie derived media handler components, which allow QuickTime to support new types of data in QuickTime movies
- clock components, which provide timing services defined for QuickTime applications preview components, which are used by the Movie Toolbox's

standard file preview functions to display and create visual previews for files
sequence grabber components, which allow applications to obtain digitized data from sources that are external to a Macintosh computer

- sequence grabber channel components, which manipulate captured data for a sequence grabber component

- sequence grabber panel components, which allow sequence grabber components to obtain configuration information from the user for a particular sequence grabber channel component

10 Marks BookWork

(c) JPEG2000 is a new image compression standard. Outline how this new standard might be incproprated into the Quicktime Architecture. Your answer need not consider the details of the actual compression methods used in JPEG2000 , instead it should focus on how given the compression format you could extend Quicktime to support it.

Sketch of ideas required by solution builds on QT Architecture knowledge above

JPEG is a still image format Need to add functionality to the following

Media Data Structure --- add knowledge of data structure on new format
Component manager --- add new component to component manage
Image Compression --- add compression **and** decompression routines to Compression manage

13 MARKS UNSEEN