SCHOLAR Study Guide

SQA Higher 2004-5

Computing Unit 3c Multimedia Technology

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Topic 4

Video data

Contents

Prerequisite knowledge

Before studying this topic you should have:

- *Basics of using video editing software (e.g. Windows Movie Maker)*

All topics require:

- *familiarity in working with the computer filing system - i.e. the ability to create, view the properties of, save and open files and folders;*
- *the ability to locate and run the necessary software for each topic;*
- *the ability to switch between multiple applications on the computer system;*
- *knowledge of units of storage (bits, Bytes, KB, MB);*

- *knowledge of the basic components of computer systems (mostly just input, output and backing store devices).*

Learning Objectives

By the end of this topic you should be able to:

- *Describe the hardware required to capture video data;*
- *Describe the structure of video files;*
- *Describe a method of compressing video files;*
- *Perform calculations involving the size and bit rates of video files;*
- *Use technical terms involved in the editing of video files;*
- *Describe the hardware factors involved in the output of video data.*

4.1 Introduction

A video is just a collection of bit-mapped images that when played quickly one after another give the illusion of a moving image.

As video files are then just lots of bitmap images, you should be familiar with Topic 2 on bit-mapped graphics before starting this topic.

We will concentrate on how video files store image data but you should remember that video files also store the sound data alongside the image data in the same file.

Just like a flick-book, a video file is simply a collection of images, except that sound is nearly always included.

Animations are often stored as video files. The only difference between a frame-by-frame animation like this one and a video is that each frame of the animation is drawn, whereas each frame of the video is captured.

Animated GIF files can store videos, but the restriction of 256 colours makes the quality very poor - this restriction has no effect here when the animation only consists of 3 colours anyway.

The LZW compression in GIF files shows its benefits for this type of image with few, flat areas of colour.

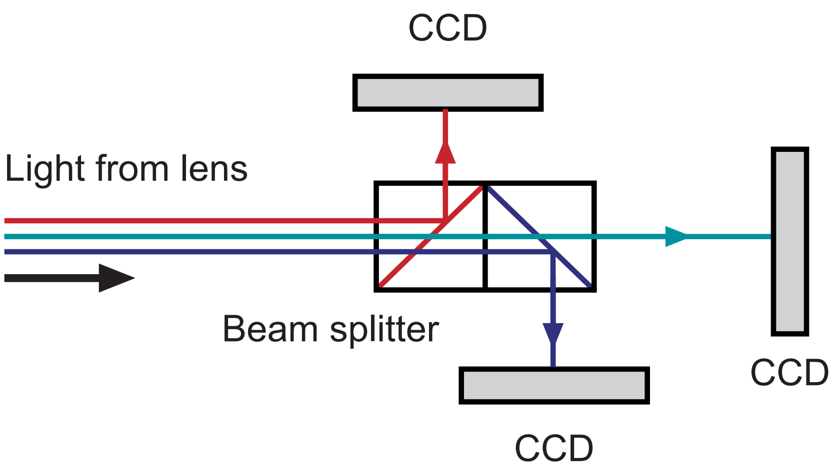
4.2 Input (capture) hardware

4.2.1 Digital video camera

Digital video cameras (from now on termed 'camcorders') work in the same way that digital cameras (from now on termed 'cameras') do. They use the same light sensors, called CCDs. The main difference is that camcorders have lower resolution CCDs than cameras and are designed to capture lots of images very quickly, capturing lots of images (frames) to form a film. For camcorders to be able to do this the ADC needs to process a lot of information very quickly, so has to be a lot faster than the ADCs used in cameras.

Camcorders do not need as high a capture resolution as cameras as the images are only designed for display on televisions or on the film screen. Moving images do not need as much detail as a still image for us to perceive similar qualities.

In order to capture the RGB image, most 'consumer' camcorders use a colour filter as in digital cameras this produces a poorer quality video than the method used by professional camcorders. Professional camcorders use 3 CCDs, each with a different filter of red, green or blue, the images from these 3 CCDs are combined to produce the full colour image. As 3 CCDs are used, rather than 1, the price of these professional camcorders is greater. (Some professional digital cameras also use this method to capture still images)



A note on convergence

Modern digital cameras include the ability to record video, albeit at lower resolutions, often including sound. They can only capture videos at lower resolutions, even although their CCDs are capable of much higher resolutions, as their ADCs cannot cope with the high bit rates required to capture higher resolution videos. Another factor preventing the use of digital cameras for capturing videos is that the storage requirement for video data is much greater than of still images and digital cameras are not usually equipped with the necessary storage space for capturing videos of any useable length.

Likewise digital video cameras often have CCDs capable of capturing images at higher resolutions than used for video (currently some have 3MP CCDs). These high resolutions are only used when capturing still images. So digital video cameras can often be used as a medium quality digital camera for capturing still images.

Perhaps by the time you read this a device will be available that can capture high quality still images and also broadcast quality videos?

4.2.2 Webcam

Webcams use low resolution array CCDs and low quality lenses, keeping costs down. As the videos captured are low resolution, there is not the need for a fast ADC as the bit rates will be lower.

A typical resolution of videos captured from a webcam is 640 x 480 at 30 frames per second (fps).

As webcams are designed and sold for the purpose of creating videos to be transmitted over the Internet, they do not need to be high resolution, keeping down the bit rates and price.

Webcams, as with digital video cameras, can also be used to take low-quality still images. The low-quality components means they are no challenge to digicams or cameras, however the quality is often more than adequate for the purpose of streaming over networks.

4.2.3 Video capture card

In order to capture videos from analogue sources such as video tape players, television broadcasts and analogue video recorders, a video capture card is needed. Some modern graphics cards include the ability to capture video, but for the best results a special video capture card is needed.

Specialised video capture cards offer several advantages over using a standard graphics card with video capture (input) capability:

- They often have faster ADCs and can capture videos at higher bit rates (i.e. better quality)
- They usually capture sound as well. This enables the sound to be fully synchronised with the video. Standard graphics cards have to be used in combination with a separate sound card, which can cause discrepancies between the video and sound tracks
- They usually have a hardware codec to allow the video to be processed and stored in a compressed format as it is being captured.

4.3 Storage of video data

Here are the approximate settings needed to capture a film to be shown on analogue television or film. Note, as these are for analogue systems, there are no pixels but the approximate resolution of each system has been calculated to be as shown below.

These are the settings you would need to capture a video in the given format at in order to maintain the quality.

	Resolution	**Frame Rate (images each second)**
Current analogue UK Television (PAL)	768 x 576	25 fps
Current USA Television (NTSC)	640 x 480	30 fps

Modern video systems are digital and improve on the image quality of analogue systems, even if the image resolution is not any greater. In digital video systems there is no snow or ghosting interference so the pictures look clearer.

Video systems of the future will support greater resolutions than these. The Star Wars Episode II film was shot on digital camcorders using an image resolution of 1920 x 1080 and 24fps.

Most camcorders are not capable of resolutions this high, these only being readily available to professional television and film makers due to their high cost.

4.3.1 Uncompressed AVI

Audio Video Interleave (AVI) files are actually a type of RIFF file (see topic 2 for more on RIFF files). As such, this container file can store videos in a variety of formats as defined by information at the start of the file (in the header).

Uncompressed video files are so large that they are almost never used. AVI files are generally used to store videos in more compact formats than un-compressed data.

The name Audio-Video Interleave is a reference to the way that audio and video data are stored in this file. When saving AVI files the audio-video interleave ratio can be set (for example embed audio data every 3 frames of the video data). This just means that the audio and video data is mixed up in the data file. This enables the videos with the sound to be played as the file is being received without having to transmit the entire file before it can be viewed.

4.3.2 MPEG

The Moving Pictures Experts Group (MPEG) have defined a series of standards for compressing video and audio using compression based on DCT (Discrete Cosine Transform) (see JPEG images). Each frame in an MPEG video is compressed as a JPEG. The data that stays the same in successive frames is then removed.

There have been a series of standards based on this:

MPEG-1 (VHS video quality with 353 x 240 pixels and 30 fps frame rate support)

MPEG-2 (The standard for DVD-Video and Digital Television -to name two. Widely used)

MPEG-3 (Intended for HDTV but these revisions were incorporated into MPEG-2) (Not the same as MPEG-Layer 3, or MP3 used for audio - this is actually the audio subset (layer) of the MPEG-2 standard)

MPEG-4 (Designed for low-bandwidth networks - e.g. video phones) (Part used by DivX)

MPEG-7 (Builds on the interactive and extra data capabilities of MPEG-4 and is a full multimedia description format) - named "Multimedia Content Description Interface"

4.3.2.1 How does MPEG work?

Not all frames are stored - just a few key frames called 'i-frames'. These are JPEGs. The next set of frames does not store images, they just store data on what has changed since the last i-frame.

First (i) frame which is the base for the following (b) frames

A scene which can use most of the inform-ation form the first

A new scene which requires a whole new (i) frame

MPEG does not store each image separately, only key frames are stored as JPEG images, the rest of the data consists of predictions or actual changes since the last (or next!) key frame.

MPEG is a lossy compression codec and, as with JPEG images and MP3, has adjustable compression depending on the desired quality, file size or bit-rate.

There are different implementations of the MPEG-4 codec (for example). The playback compatibility and compression/quality gained depends on the actual version of the codec that is being used.

4.4 Calculations

As video files are simply a collection of bitmap images, all we need to do is calculate the size of one image (i.e. one frame) and multiply that by the number of frames in the entire video.

File Size (Bytes) = Frame Size (Bytes) x Frame Rate (frames per second [fps]) * Video Time (s)

As video data is time-dependent, the term bit-rate is often applied to it.

Activity

Calculate the Bit-rates for the two video files shown in section 4.2.1

Use the above formula to calculate the size of the uncompressed file - verify that it matches (approx) the actual size of this file.

The uncompressed file was initially captured using 24 bit colour depth. What would have been the size of this file?

What would the file size have been if it was captured at appropriate settings for display on UK TV? (24 bit colour depth)

These figures are all for a nine-second video clip. Perform the calculations again, this time for a 3 minute 12 second video (long enough to store a music video for instance).

These calculations above are all regarding a video file without any sound. What would the uncompressed file size of the 3 minute 12 second music video be if it were recorded for maximum quality on UK television with CD quality stereo sound in PCM format?

Find or create a video file, you could use one of the video files from this section of work, capture your own video or use any other video file

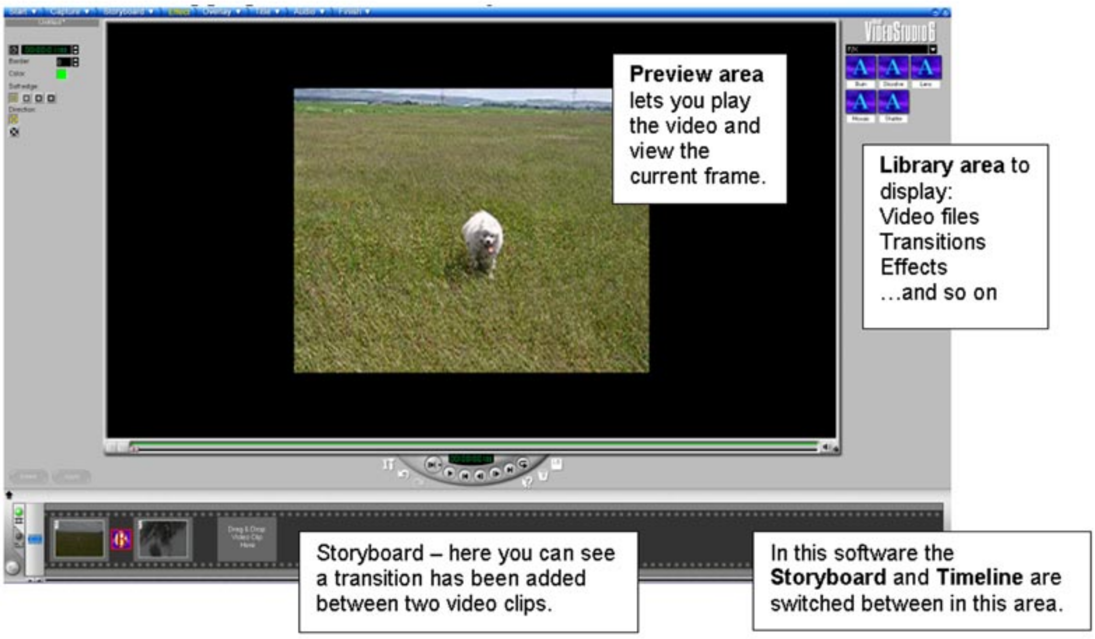
- Open up the video file in video editing software
- Use 'Save As' (or the method appropriate to your software) to save the video using different settings. Remember to reload the original before each save.
- Fill in this table showing your findings

Codec used	Frame Size	Frame Rate	Colour Depth	Duration (all the same)	File SIze	Quality

Try at least 2 different codecs (uncompressed AVI and MPEG?) Use 6 different settings to see the effect on file size and video quality.

4.5 Technical terms

Most video editing programs have a similar layout:



4.5.1 Timeline

The timeline is a key item in a video editor. Here, each frame of the video is displayed as a thumbnail image. This allows each frame to be manipulated separately or overlays and effects applied to a group of frames.

An overlay could be another video, animation, title or effect such as a colour gradient. Effects can also be applied to a single or number of frames - effects that are available in bitmap editing programs are also available to be applied to video.

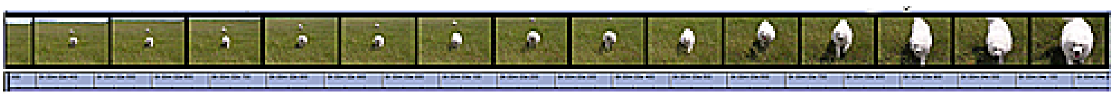


Figure 4.1: A timeline

A library of effects that can be applied to frames on the timeline.

4.5.2 Transitions

Transitions are effects that are used to join two video clips (or shots) together. Common transitions are Fade and Wipe.

4.5.3 Sequencing

Sequencing just means joining together video clips into different orders. This is done on the 'Story board' of the video editor as shown above. Transitions can be added to connect different clips on the storyboard.

Applying effects to videos

Open two videos in editing software, apply a transition, titles and an effect. Save them as MPEG video files.

4.6 Output hardware

As mentioned in the topic on bitmap graphics, the graphics card is responsible for the output of image data.

Due to the complex codecs and high bit-rates needed to output video data, video output cards used to be needed in order for a computer to be able to display videos at full quality.

Graphics cards have become much more powerful (driven mainly by the games market) and any modern graphics card should be able to comfortably decode and display full-quality videos on a computer.

4.6.1 Digital to Analogue Converter (DAC)

While most people have analogue displays (LCD displays with digital (DVI) inputs are available) then graphics cards must be able to generate the analogue signals needed for the monitors.

The DAC changes the digital video signal in the computer into an analogue video signal that the monitor can use to display the image.

4.6.2 Digital Signal Processor

The Digital Signal Processor (or **GPU**) plays a key role in allowing computer to display full-quality videos.

The GPU on the graphics card is responsible for decoding the video signal and may even have hardware codec built in. There are fewer calculations needed to output video data than to capture it (it is an asymmetrical process) - for MPEG video files.

Preparing a video file

Using knowledge from this unit, prepare a video file and insert it into one of the multimedia applications you created in Topic 1.

4.7 Questions

Q1: Which of these does **not** describe a why a video capture card is a better choice for capturing video data than a standard, all-round graphics card with 'video in'?

a) The 'video in' on the graphics card does not allow analogue video to be captured

b) Video capture card has a faster ADC and can capture the video data at higher quality
c) Video capture card also allows sound to be captured, which the standard graphics card does not
d) Video capture cards can compress the video data as it is received

Q2: Look up a computer catalogue (paper or web site - e.g. www.dabs.com) and compare the features of a standard graphics card with video capture (look for VIVO - video-in, video-out) and compare the price and features with a Video capture card. Create a table to summarise your findings.

Q3: Highest quality PAL television is approximately: 768 x 576 pixels at 25fps in 24 bit colour. What bit-rate is needed to broadcast this, uncompressed, over a digital network?

a) 52Kbps
b) 4Mbps
c) 32Mbps
d) 440Mbps

Q4: What bit-rate is needed to broadcast NTSC television?

Q5: AVI (Audio Video Interleave) is a file format that can be used to store video. Which codec is used to encode the video data in an AVI file?

a) It is uncompressed, so no codec is needed
b) MPEG
c) AVI
d) Any, information on the codec to use is contained in the header of the container AVI file

Q6: Explain how MPEG codec works.

Q7: A video is captured using 24fps and 600 x 400 pixels, colour depth 24 bits. Which of these settings would **half** the file size of the uncompressed video?

a) 24fps, 600 x 400 pixels, 12 bits
b) 6fps, 300 x 200 pixels, 12 bits
c) 12fps, 600 x 200 pixels, 24 bits
d) 12fps, 300 x 200 pixels, 24 bits

Q8: Calculate the bit-rates and file sizes of all five files in the above question.

Q9: When a news report is shown it appears by sliding down from the top of the screen. What has been used to create this effect?

a) A transition was used
b) Sequencing was used
c) The frames were edited on the timeline
d) The video was saved using a special codec

Q10: What is the difference between an effect and a transition? Make a list of all the effects and transitions supported by your video editing software.