DIGITAL VIDEO IN TRAINING

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ABSTRACT

The training industry is witnessing a transition from analog video stored on tape or videodisc to digital video stored on computer disks or CD-ROM. New compression techniques are making digital video technology more feasible for instructional applications such as interactive training, desktop video editing, and video conferencing.

There are several advantages to storing video in digital form. Digital video can be copied and reproduced without any loss of quality; whereas, each time an analog format is duplicated, the quality decreases and the noise level (imperfections) increases. In addition, digital formats offer the potential for increased manipulation; the images can be repositioned, resized, and recolored by a computer. Video in digital formats is also easier to transmit over computer networks.

This presentation will provide an overview of various digitizing and compression techniques for video. In addition, digital technologies such as QuickTime, Video For Windows, and Digital Video Interactive will be outlined. Demonstrations of various compression techniques will be included, and guidelines will be provided for selecting and implementing digital video in training applications.

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INTRODUCTION

For many years, interactive video in industrial and military settings relied on videodisc technology. Videodiscs provide 30 minutes of full-motion, full-screen video with two audio tracks. The video images on videodiscs are stored in analog format -- just like videotapes. Although analog video offers realistic colors and efficient storage, it requires a videodisc player and video monitor as part of the delivery configuration.

Recent advances in large storage media and digital compression techniques have provided the potential to record, edit, and store video in a digital format. This paper outlines the advantages and disadvantages of digital video and presents an overview of digital compression techniques and procedures.

ADVANTAGES AND DISADVANTAGES OF DIGITAL VIDEO

There are several advantages to storing video in digital form, but there are also some limitations. This section outlines the features and restrictions of digital video for training applications.

Advantages

High Quality Duplication. Digital video can be copied and reproduced without any loss of quality; whereas, each time an analog format is duplicated, the quality decreases.

Manipulation by Computer. Digital formats offer the potential for increased manipulation by a computer. With desktop video editing software, the images can be repositioned, resized, and recolored.

Networkable. Video in digital formats is easier to transmit over computer networks. Video teleconferencing over LANs and digital phone lines is possible with digital video.

One Monitor. A major advantage of digital formats (versus analog videodisc format) is the hardware requirement. With digital formats, the computer monitor can display both video images and computer graphics.

Disadvantages

Large File Sizes. A major impediment to digital systems is that digital video requires an enormous amount of computer storage space. For example, when one videodisc frame is digitized, a file of roughly one megabyte is produced. Without compression, less than 30 seconds of motion video can be stored on a CD-ROM disc.

Slow Transfer Rates. Another limitation to digital storage is the relatively slow data transfer rates of CD-ROM technology. At current transfer rates, it is difficult to display full-motion video at 30 frames per second in digital form.

Decreased Quality. The quality of the majority of the digital video currently available is less than the quality provided by VHS tapes.

COMPRESSION TECHNIQUES

In order to reduce the size of the digital video files, a variety of compression techniques can be used. General-purpose data compression programs, such as StuffIt, DiskDoubler, or PKZip have been around for years. These programs are used to compact computer programs and files for transfer or storage. For example, most of the files on the Internet are compressed by general-purpose programs, and many of the commercial software programs are distributed in compressed form because they require less diskettes. General-purpose compression programs can be referred to as "lossless." This means that when the file is decompressed it will be the exact size and hold the exact information as the original file.

When dealing with video compression, lossless compression is not powerful enough because they only allow you to reduce images at ratio of less than 4:1 (Anson, 1993b; Guglielmo, 1993). "Due to the huge size of digital image files, much larger compression ratios are needed [for video] and so most research into image compression has been applied to lossy compression schemes" (Anson, 1993a, p. 18). With lossy compression, some data is thrown away when the files are compressed. However, the lossy algorithms are "designed in such a way that it is difficult to see the loss, or at least so that crucial information is not lost" (Stern & Lettieri, 1994, p. 94).

Video compression techniques either employ spatial compression or temporal compression. In spatial compression (also referred to as intraframe), redundant or extraneous information is discarded on each screen. For example, if a portion of the screen is the same color, an algorithm will contain the information for that area of the screen, rather than storing information for each pixel. Spatial compression works well for images and still frames; however, it limits the compression possible for motion video.

In temporal compression (also referred to as interframe), redundant information is eliminated *between* screens. In other words, if the background of the scene does not change, the computer would save the first frame in its entirety; then for the next few frames, it will save only the parts of the screen that change. Most of the compression for motion video employs temporal compression because substantial redundancy exists between most frames and the compression ratio can be much higher.

CODECs

Compression programs are called "codecs," which stands for compressor/decompressor. Several codecs have been developed in the past few years; the sheer number of new hardware and software products for compression of video "is almost intimidating" (Nelson, 1994, p. 56). Some of the products provide proprietary compression algorithms, while others are adapting to emerging industry-standard techniques (Child, 1993). Some of the more common codecs include JPEG, MPEG, and Fractals. The compression scheme you choose depends on the desired resolution of the image, the storage space available, and the processing speed of your computer (Guglielmo, 1993).

JPEG

The international standard created by the Joint Pictures Expert Group (JPEG) is a compression technique that utilizes spatial compression for still frames. "JPEG compresses images at ratios of approximately 20:1 without noticeable loss of quality" (Guglielmo, 1993, p. 30). Although is JPEG is excellent for individual images, it does not offer enough compression for motion video, in which there may be up to 30 images per second. Another limitation of JPEG is that it does not include a standard for compression of an audio track.

MPEG

The Moving Pictures Experts Group (MPEG) developed a non-proprietary standard for motion video compression. The MPEG standard uses temporal coding to eliminate redundancy between frames, along with spatial coding to compact the information inside individual frames. Through MPEG, video compression of up to 50:1 (twice that of JPEG) can be achieved without noticeable loss. A disadvantage of MPEG is that most of the frames cannot be accessed individually. The MPEG format has been endorsed as the standard for CD-video that can provide linear movies on CD-I discs, and a new standard (MPEG-2) is being developed for broadcast video (Baron, 1992).

Fractals

Fractal compression is a powerful new technique that is appearing in the field. With Fractal compression, mathematics are employed to consider the similarities of objects and images. For example, "a fractal compression routine might find a way to approximate the image of a leaf out of three smaller versions of itself, overlapped" (Warren, 1993, p. 5). The image can then be represented by linear equations that only require a few bytes of memory. Fractal compression offers the advantages of fast decompression speeds, resolution independence, and much higher compression ratios than the other techniques (Anson, 1993b).

DIGITIZING VIDEO

To develop digital movies, a video digitizing card must be installed in a computer. Creating, editing, and playing digital movies usually involves several different software programs, including video capture software, video editing software, and digital movie players.

Video Capture Software

The first step in creating a digital movie is to "capture" the video. Capturing refers to converting the video from an analog source into a digital computer file. This process requires that a video digitizing board be used. These boards must be purchased and installed, unless the computer already has digitizing capabilities. The conversion process makes it possible to use a video camera, videotape, videodisc, or broadcast television as an input device and to display the video on a standard computer monitor.

A software capture program is used to control the capturing process. Decisions on frames per second, color depth, display size, and compression program affect the file sizes and the playback quality of the digital video. For example, a designer could record video at 15 frames per second instead of 30 frames per second or chose to set the display size at 1/4 of the screen, rather than the full screen. Both of these approaches will result in smaller file sizes. In general, the video capture procedure includes these steps:

- Connect a video source to the digitizing card
- Open the video capture software program
- Click on the "Record" button to start the recording
- Click on the "Stop" button for the end point
- Click on "Play" to preview the video clip
- Change the start and stop points, if necessary
- Save the file and give it a name

Video Editing Software

Although a minimal amount of editing can be done with the video capture programs, there are several powerful programs that specialize in video editing. One such program is *Adobe Premier* by Adobe Systems Incorporated. Video editing software allows you to sequence video clips, add graphic pictures and animations, and incorporate sound and visual effects. For example, if you have two video clips, you can change their length and join them together with a transition by using video editing software.

Video editing software is becoming very sophisticated, and many companies are using it to edit videotapes as well as digital video. In some cases, it is taking the place of extremely complex analog video editing equipment.

Digital Movie Players

The editing programs can also play the movies; however, software that is designed to play digital movies is available. Most movie players utilize a standard controller. The controller has the following options:

- Set audio level
- Play movie
- Pause movie
- Step through movie
- Slider bar to select a particular part of the movie

Movie-Savvy Applications

Many applications, such as Word Perfect, Microsoft Word, and Filemaker Pro, can now recognize and import digital movies. For example, you could write a resume in Word and embed a short movie into the document. It is important to note that the movie is not actually embedded into the document -- only the "pointers" to the movie are there, and you need to place the movie file on the same diskette with the resume.

Most of the hypermedia authoring systems now recognize and play digital movies. Programs such as HyperCard, HyperStudio, and ToolBook can incorporate buttons that show, hide, or play movies, based on the user's actions.

DIGITAL VIDEO TECHNOLOGIES

Until recently, most of the digital video that played on computers required special hardware. For example, Digital Video Interactive (DVI) has been around for years, but a special DVI-capable board is necessary for both capture and playback of the video. Two software technologies, QuickTime by Apple Computer and Video for Windows by Microsoft, have provided desktop video without special hardware.

Digital Video Interactive (DVI)

Digital Video Interactive (DVI) is a technique to digitize and compress video, which can then be stored on a CD-ROM disc or hard drive. A special computer board, made by Intel Corporation, is used to decompress the video on a computer when it is played back. This technology allows up to 72 minutes of full motion/full screen video to be stored on a CD-ROM. That is a tremendous amount of motion video when compared to the 30-minute limit of a

12-inch videodisc. DVI can also store other digital information, such as audio, text, and graphics.

QuickTime

QuickTime is a new format that was developed by Apple Computer Company to enable Macintosh computers to compress and play digitized video movies. A digitizing board is required to capture video for a QuickTime movie, but any color-compatible Macintosh computer can play the movies without additional hardware. The video is automatically compressed when the movie is created and decompressed when it is played back. Because QuickTime is a recognized Macintosh file format, the movies can be pasted or imported into a variety of Macintosh applications such as work processors, spreadsheets, and HyperCard.

Most QuickTime movies currently play in a small window on the Macintosh monitor (about one-quarter of the screen or less). Although the size can be expanded, the speed of the movies decreases substantially when you do so. In most cases the movies play at about 15 frames per second. The actual rate (frames per second) depends on the speed of the computer. For example, a movie on a Macintosh LC will play at a slower rate than the same movie on a Quadra or similar high-end Macintosh. Several codecs are available in QuickTime; others can be added as they are developed.

Video for Windows

Video for Windows is Microsoft's answer to software-only digital video for computers (Beer, 1993). It requires at least a 386 computer, 4 MB of RAM, and a digital audio card that is compatible with Microsoft's multimedia extensions. Similar to QuickTime, Video for Windows offers an easy to use interface to edit and play video clips without additional hardware.

CONCLUSION

Desktop digital video offers great potential for interactive training and videoconferencing in industrial and military settings. For example, instead of producing a videodisc to illustrate the procedure for performing maintenance on a helicopter, the video can now be digitized, saved as a QuickTime movie, and stored on a CD-ROM. As compression techniques improve, computers become faster, and alternatives for storage improve, the trend toward digital video in training applications is likely to continue.

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