Everything You Ever Wanted to Know About Digital Video, but Didn't Know How to Ask
&
Competitive Analysis
(EyeQ vs. Digital Film)

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This primer will give you a basic, not-too-technical overview of digital video, compression algorithms, SuperMac's Digital Film board, and New Video's EyeQ.

Digital Video

Overview

It has long been a dream that computers would be usable for digital random access editing. Although there have been Digital Video editing (DV editing) systems on the market for some time, their high prices have limited their use to the very largest institutional producers of video material. One important factor in the price of these high-end systems has been the very large high-performance hard disks they require. Since one frame of video generally takes approximately one megabyte (MB) of storage; and since video tape runs at 30 frames-per-second (fps); one second of uncompressed video takes approximately 30MB of storage, and the disks have to be capable of writing and reading at sustained rates of 30MB per second or more.

Two important technology trends have been converging to help create lower cost solutions for DV editing. First, the cost of hard disk storage is coming down. Most professionals can easily afford a one gigabyte (1,000 MB) hard disk drive today. Therefore, they can store more video less expensively. Second, compression technology has developed to the point where video compression hardware and software can compress video at ratios from 25 - 200 to 1 while maintaining fairly good quality. This means the video takes much less storage space and can be recorded to and played back from standard computer hard disks which average read/write rates in the 500KB to 1.5MB per second range. The combination of better compression technology and inexpensive mass storage devices has paved the way for low cost DV editing systems.

Traditional video editing is expensive and time consuming. DV editing dramatically cuts both the time and costs involved in editing. Instead of shuttling your video back and forth in search of a segment, DV editing allows the editor to jump directly to the proper video frame. DV editing makes it much easier to insert a new video segment–it literally takes seconds. Traditional editing tools would require you to recompose the entire tape, which could take hours. DV editing also makes special effects easy and inexpensive. Special effects are one of the most expensive items to add in the traditional video editing process. DV editing not only makes adding effects easy, but it also makes new kinds of effects possible.

The question to now ask is, "how can we use this digital video?" There are three ways to utilize digital video: on-line editing for analog videotape output (AVO), off-line editing, and multimedia usage.

DV Editing for Analog Videotape Output (AVO)

On-line DV editing is the capability of editing digital video and outputting the end result directly to analog video tape. The goal is “broadcast” quality videotape output. The reality at this time is “industrial” quality.

Of all of the characteristics of digital video, image quality is the overriding requirement for AVO. The AVO market will not mind buying larger storage devices for their digital video as long as the quality is high enough for analog videotape output. The comparative costs between larger storage devices and traditional video editing equipment more than cost justifies using AVO. Other important characteristics of the digital video such as file size, data rates required for transmission and playback, networkability,

cross-platform compatibility of the compressed data files, and inexpensive decompression and playback take a back seat to image quality for AVO.

Off-line DV editing
The quality possible with today's digital video technology cannot at this time be considered "broadcast". However, today's DV editing solutions will be acceptable for off-line editing. With products like Adobe Premier 2.0 you can output a SMPTE timecode compatible list called an edit decision list (EDL). This allows you to use DV editing for off-line editing and previewing. The final high-quality broadcast tape will be auto-assembled at a video post production facility using the master tapes and the EDL produced on the DV editing off-line system.

Digital Video for Multimedia
Until recently, in order to incorporate video in a multimedia application (such as computer based training systems, information kiosks, or presentations) an attached analog video device (such as a laserdisc, VCR or camcorder) was required. In addition to the computer, two pieces of equipment were needed: a video device and a video board that could accept and display video on the Mac screen. Until now, Laserdisc has been the video device of choice because of its random access capability and quality.

There are important advantages in using digital video for multimedia. Using digital video makes it easier and far less expensive to replace and update segments of video. Using traditional methods, an entirely new laserdisc or videotape has to be created each time any modifications to the application are needed. This places severe restrictions on both the quality and timeliness of a video presentation. Digital video kiosks, for example, can be updated with new material daily via a network download, and training materials can be kept up to date in even the most volatile industries. Digital video also eliminates the need for having a separate video device attached to every Mac. The video files simply need to be loaded onto a hard disk or a networked server. This simplifies many aspects of system management and increases overall system reliability.

The critical issues in the selection of a digital video product for use in multimedia applications are the file size per minute of video, the data rate required for video playback, cross-platform compatibility of the video files, access to inexpensive playback solutions, and of course, quality.

Compression Algorithms
A compression algorithm is a method for compressing data. Video compression algorithms are compression methods that are specifically geared for handling the data created by digitizing full-motion video. There are quite a few algorithms on the market, each one slightly different. New Video believes that there will not be one algorithm that meets every video compression requirement. Different algorithms are suited for different uses. Some are optimized for quality – at the expense of file size and data rate. Others are optimized to minimize file size and data rate – sometimes at the expense of quality.

Real time (symmetrical) compression means that video is captured and compressed at full video frame rates (NTSC = 30 frames per second). This term has been badly misused by a number of companies selling video digitizing boards. Though these companies claim to digitize video in "real time," they are only able to capture 1 frame of video in 1/30 of a second. That is still frame capture, not real time video digitizing. When referring to the capability of real time digitizing New Video means the capability of digitizing, compressing and storing video at 30 fps.

Video can also be compressed asymmetrically. Asymmetric compression means that the compression process is done in a non-real time process after the capture process has taken

place. Asymmetric compression processes differ in their degree of asymmetry. This degree or level will usually be referred to by a ratio like 150:1. A compression process with 150:1 asymmetry will take 150 minutes to compress 1 minute of video. Of course, a better way to measure asymmetry is by measuring how much time it takes to compress one frame of video. This is a more accurate measurement of the asymmetry of a particular algorithm.

The following is a brief description of some of the algorithms that are either currently shipping or are thought to be close to commercial release in some form:

•PLV 2.0: PLV (Production Level Video) provides extremely high quality digital video at extremely low data rates. The average storage size of a PLV file is 9 Mb per minute for full-screen, 30 fps video with 16-bit audio. PLV defies the norm for compressed video by providing extremely high image quality at a

data rate that can be played directly from a CD-ROM in real time. It is designed for large scale content publishing. PLV is cross-platform compatible with any system running a DVI compatible board. It requires an outside service bureau for compression. Compression services currently cost $250 per minute of video.

•"Motion" JPEG: Though JPEG is a CCITT/ISO standard for still image compression, "Motion" JPEG is not a standard for video compression. File format, audio compression, audio synchronization and system integration, all of which are vital to a motion video compression standard, are not defined in JPEG. Of the many versions of "Motion" JPEG none are compatible with one another. Some companies selling "Motion" JPEG based boards are claiming that it is the "successor" to DVI algorithms. Don't be fooled. "Motion" JPEG has nothing to do with MPEG nor is it a successor to DVI. Though to give "Motion" JPEG its due, it is good at one thing. It creates high quality digital video that is well suited for on-line DV editing for AVO. Of course, that comes at a price. The price is 35 - 60 MB per minute for disk storage. Certainly unacceptable for multimedia usage.

•True Motion (CEC): Upon release, this will be the highest quality algorithm on the market. It is capable of both real time and asymmetric compression and is suitable for multimedia applications and off-line DV editing, as well as on-line DV editing for AVO. This algorithm represents a major advancement in the quality of digital video. CEC comes one step closer to the "broadcast" quality sought by so many professional video people.

•Indeo: Indeo is a real time algorithm that is acceptable for on-line DV editing for AVO (with lower quality results than CEC or Motion JPEG) and is optimized for off-line DV editing and multimedia. File sizes are small and are adjustable depending on the level of quality you choose and you have access to every frame–just like "Motion" JPEG. In addition, Indeo files can be played back with or without hardware. Utilizing New Video's Indeo QuickTime software codec, any Mac running QuickTime 1.5 can play an Indeo file. Indeo plays back with hardware acceleration at 30 fps at up to a full size window. In software it will play back at 15 - 24 fps in smaller windows and delivers approximately Compact Video (see below) results. Indeo is the only algorithm that can be played in both hardware and software-only environments and it is the only software-only playable algorithm that is compressed in real time. Indeo is also cross-platform compatible with any system running a DVI compatible board, and will soon be able to play back without hardware on any Windows based system running QuickTime for Windows.

•Compact Video Compressor (CV): CV is a new software only algorithm that is shipping with QuickTime 1.5. It provides larger window sizes and better frame rates and quality than Apple Video Compressor (see below). CV is 150:1 asymmetric at its higher quality settings (it requires 3 hours or more to compress 1 minute of video even on Quadra-class machines). It requires between 15 to 30 seconds per frame for compression depending on the quality selected. This high asymmetry makes CV most suitable for large scale distribution of video and for very small scale desktop projects. While it improves on AVC's image quality, it won't replace it. Average CV file sizes are very large as well. Expect 320x240 pixel windows at 15-24 fps to take about 30 Mb per minute of storage space and approximately 5 hours to compress.

•Apple Video Compressor (AVC): This is the original software only algorithm (Road Pizza). It will continue to be an option for software only playback of video files under QuickTime. It is not nearly as asymmetric as CV (it's only 45:1 asymmetric) and will run on all Macintosh systems. Expect 160 x 120 pixel sized windows running at 12-20 fps (depending on the type of Mac you are using) and about 25 Mb per minute of storage space.

•MPEG: As of November 24, 1992, MPEG has cleared Proposed International Standard, but is not an acclaimed international standard as of yet. Although you may encounter some hyped up claims about MPEG chips and boards, New Video believes that the MPEG boards expected within the next six months are decompression chip sets only. Since MPEG is currently 200:1 asymmetric on a Sun Workstation (SPARC Station 4) when compressing, and since it uses frame differencing, it will be relegated to the same class of use as PLV. However, New Video is committed to supporting MPEG in the future. While MPEG solutions are currently being worked on that will run on the EyeQ hardware, MPEG solutions are not practicable at this time.

Algorithm	Storage per 1 min of video and audio	Compression Type	Primary Usage	Availability

True Motion (CEC)	15 - 30 MB	Real time and Asymmetric (10:1)	On-line AVO /Off-line DV editing and Multimedia	Unknown - will run on EyeQ
PLV 2.0	8 - 12 MB	Asymmetric (Off-line)	Multimedia	Ships with EyeQ
Motion JPEG	35 - 60 MB	Real time	On-line AVO /Off-line DV editing	Ships with Digital Film
Indeo	5 - 16 MB	Real time	Off-line DV editing and Multimedia	Ships with EyeQ & QuickTime 1.6
Compact Video (CV)	Variable	Asymmetric (150:1)	Multimedia	Ships with QuickTime 1.5
AVC	Variable	Asymmetric (45:1)	Multimedia	Ships with QuickTime 1.5
MPEG 1.0	Approx. 9 MB	Asymmetric (200:1) on Sun SPARC	Multimedia	Unknown

There are different algorithms for different applications. You must first determine your application requirements with regard to platform, image quality, symmetrical vs. asymmetrical compression, file size and data rate in order to determine which compression algorithm you should use and ultimately which digital video board you should select.

Digital Film

SuperMac has been showing this product for more than 2 years. When it ships, it will utilize "Motion" JPEG, the pros and cons of which are discussed in the previous section.

Pros

The main use for SuperMac's Digital Film board is DV editing for AVO. Because "Motion" JPEG does only intraframe compression, and because the image quality is high, it is ideally suited for editing files for AVO. Digital Film currently grabs video in real time at 640 x 240 pixels at 50:1 compression ratios resulting in file sizes of 35 - 45 MB per minute. In order to create a full-screen size of 640 x 480 Digital Film uses "blind doubling" to double pixels horizontally and achieve the 480 line resolution of "full-screen". At their higher quality 25:1 compression ratio setting Digital Film is actually capturing a 320 x 240 window and using pixel interpolation to achieve 640 x 480 resolution. This results in file sizes of approximately 60+ MB per minute of compressed video. The quality of the video output is very good. It is not, however, "broadcast" quality.

Cons

Because Digital Film is based on the "hardwired" CL550B processor from C-Cube, it can run only one video compression algorithm – "Motion" JPEG. The file sizes that Digital Film creates are very large. Generally speaking, their video files run between 35 and 60 MB per minute. This means files 2 to 4 times larger in size than files created by EyeQ. While this may be OK for some files used for digital video output, it is definitely not OK when you want to use those files for multimedia.

Also, because "Motion" JPEG requires high data rates for playback, Digital Film cannot create files that play from CD-ROM or over a network in real time and at full-screen. Even if a CD-ROM is not the delivery medium, using Digital Film will require four times as much hard disk storage space as EyeQ for an equivalent amount of video. Hardly a cost effective solution.

Digital Film is an authoring solution only. SuperMac's playback solution is to convert their Digital Film files to software only (using CV) resulting in files that are limited to current software only playback performance. Again, Digital Film is not a good solution to create digital video for multimedia.

The net on Digital Film is this. If you want a single purpose digital video board for on-line DV editing for AVO and you don't mind paying SuperMac's premium price for it, buy a Digital Film board. However, read on if you are interested in a complete digital video solution.

EyeQ

Pros

EyeQ is a complete digital video solution. Because it is based on programmable technology, it is able to compress and decompress a wide range of algorithms. This makes EyeQ extremely versatile. EyeQ can currently compress and decompress the Indeo video algorithm and can decompress the PLV video algorithm. In the near future, EyeQ will be compressing and decompressing the CEC video algorithm as well as software only formats such as CV and AVC. This means that EyeQ will be the only hardware accelerator for *every* compression algorithm available under QuickTime 1.5. Authors will be able to capture and compress video in real time using any QuickTime algorithm, and will be able to play that video back with or without hardware on any QuickTime platform. In addition, there are algorithms planned for teleconferencing and other specialized applications on the horizon. And since EyeQ is based on programmable technology, EyeQ will be upgradable via software. Furthermore, EyeQ is not limited to just video compression and decompression. EyeQ will also be able to accelerate graphics applications at up to 300%. Again, it will only take a software upgrade to extend the capabilities of EyeQ.

Since EyeQ can utilize a variety of algorithms, it can create digital video files that can be used for multimedia or AVO. EyeQ can produce files that can be played back from CD-ROM at full-screen and 30 fps, can play over standard networks, and can be played cross-platform on any system running a DVI compatible board. EyeQ can also produce files that are ideal for output to analog videotape.

- •Algorithms for multimedia: PLV and Indeo
- •Algorithms for AVO: CEC (future algorithm)
- •Graphics processing acceleration for popular graphics applications (Q1/2 '93)

With compression ratios up to 160 to 1, it's easy to see why EyeQ files take so little room on your hard disk. In fact, EyeQ provides as much as 400% better compression than its competitors. EyeQ files are at least 4 times faster to transfer over networks than any of its competitors' files.

EyeQ also has a playback only solution. If you want to have an entire classroom playing back EyeQ files at full-motion and 30 fps, you need only an EyeQ Playback Solution in each system. This represents a more cost effective solution than Digital Film. Also, Indeo files captured by EyeQ can be played back using New Video's software codec in QuickTime 1.5 systems without EyeQ hardware. Our software-based Indeo QuickTime codec allows software only playback of Indeo files on the Mac. Furthermore, the same files can be played back in QuickTime for Windows on a PC. This cross-platform compatibility ensures that the file you create on you Mac with EyeQ can be played back by anyone with a Macintosh or PC (with Windows), with or without DVI hardware! Talk about compatibility.

Cons

The technology on which EyeQ is based (DVI) has been slammed by our competition for offering an algorithm that does something that their "solutions" will never be able to do. That is, play back files that produce a very high quality video image at low enough data rates to play from CD-ROM at full-screen size and at 30 fps–PLV. PLV has been attacked for requiring off-line processing by a compression facility. Our competition would love for you to believe that there is only one of these in the entire country, and that compression services are expensive and slow. In fact, there are now five licensed PLV compression facilities with more on the way. The current cost is $250 per minute of compressed video and turnaround time is generally one to two weeks. Although PLV is less convenient and often more expensive than desktop compression, it provides the optimum solution for video publishing. PLV compression is to desktop compression what Linotronic printing is to LaserWriter printing. It is a final step in the production process that can be used to achieve the highest quality video files for use in content publishing, training, kiosks, or any environment where

high quality video is needed at extremely low storage rates.

Indeo, our current algorithm for desktop compression, captures at lower resolutions than Digital Film. At a maximum of 320x240 capture it is roughly half the resolution of a Digital Film frame at its highest quality setting. Indeo is an algorithm that is targeted for multimedia usage and is not primarily used for on-line DV editing for AVO. Digital Film would make a better choice for on-line DV editing for AVO applications today. However, the CEC algorithm, which is now running on EyeQ and will be released in

the near future, provides both higher resolution (768x240 and 60 field per second) capture and compression, providing the highest quality digital video available on the desktop.

Conclusion

Hopefully after reading this you will have a better understanding of digital video technology. The determining factors which will help you decide which digital video product to purchase will be how you use that digital video. New Video believes that in providing you a flexible, software upgradable, multi-purpose digital video product that you will be able to accomplish all that you want with our EyeQ products.

This is a first draft of New Video's educational primer on digital video. We have tried to be fair to our competition in reporting what they are good at as well as what they are not. We are more than willing to correct any factual errors in this document in order to represent other products fairly. Please feel free to contact:

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