Digital Video Production

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Overview

Viewing video productions is a popular activity in this day and age. It might be at a movie theater, over cable television, on DVD. Millions of video streams are distributed to viewers with a broadband internet connection daily. However, there is something mystical and wondrous surrounding the production of truly high-quality video. Coupled with the complexity of production tools, a lack of knowledge helps keep the promise of delivering quality video elusive. Given that production equipment is within the budget of most hobbyists, and the fact that software applications are highly evolved and easy to use, the door has been flung open to anyone with creative ideas and the incentive to learn how to produce digital video. Anyone can point a smart phone at a subject and press the record button, but producing professional quality digital video involves these steps:

1. **Plan the Production:** Identify your audience and your objectives. Create a storyboard, a schedule, a budget, and determine the methods of delivery that will be used. Test the results of the process from beginning to end on a few short clips.
2. **Shoot the Video:** Select a format and record your video with a high-quality camera, logging your scenes carefully as you shoot. Take care to light well, keep backgrounds still, and monitor the audio. Shoot in the highest resolution video format available.
3. **Transfer or Capture the Video:** If you recorded with a camera or camcorder, import the video directly to your hard disk. Using an SD card is a quick way to move files. If analog tape is the source, encode it with a capture card on a computer optimized for video capture. Do not compress the video at this stage.
4. **Edit and Add Effects:** Use a non-linear editing program to add titles, transitions between scenes and special effects. Sweeten the audio track as needed. Save the edited file uncompressed and archive it. This may require a lot of storage space.
5. **Compress the Movie:** Apply your choice of codecs for distribution. The architecture selected for delivery may dictate your compression choice. Adjust the contrast and picture quality, testing various bit rates, frame rates, and resolutions on the target platform.
6. **Prepare for Distribution:** For DVD, build an interface with an interactive authoring tool and burn a DVD-Recordable disc with the digital video files. This is typically MPEG-2 video and AC-3 audio. For YouTube, deliver an MP4 file with the H.264 or H.265 codec, 10-20 Mbps, 16x9 (720x1280 or 1920x1080), with AAC-LC audio.

1. Plan the Production

First, determine exactly what you hope to accomplish with your project. Evaluate the target audience and the requirements of delivering video to them. With a clear idea of the project goals and audience, choose the delivery methods. Then create project specifications, a storyboard, and a script. If this is a work for hire, the client should approve the project plan in writing prior to production.

Determine Your Goals

What are you trying to communicate to the viewer? How will it be delivered? If it will be online, how many users will need to be able to access it simultaneously? Will the media be viewed in a linear fashion, or will it be part of an interactive experience?

Determine the Minimum System Requirements for Playback

Make these decisions early in the planning process. Higher quality video requires a fast connection to the server. Will viewers need to have specific software installed? It may be wise to prepare multiple versions of the video files and deliver the most appropriate version to each platform.

Choose the Technologies and Tools

Make sure the technology can support your goals, required media types, playback platforms, and interactivity. Select the hardware and software that will be used to create the project, including audio/video capture hardware, editing software, compression tools, codecs and encoders, authoring software, DVD burners, HTML tools, and media servers. The MP4 architecture is a system extension that is widely used. Applying a codec, such as H.264, makes the video and audio compact enough to stream over the web. Each codec has different characteristics and applications. A format is the file description in which files are stored and are part of an architecture. The QuickTime movie file format (.mov) can easily be converted to MP4.

Architectures

An architecture controls how dynamic media is handled by a computer, including how movies are displayed. The various architectures have some features in common, but there are differences between them. Selecting the architecture depends on the video application and the delivery platform.

QuickTime and Windows Media are examples of digital A/V architectures. Each of these includes software components that provide for the creation, storage, and playback of media; each defines standard formats for storing media, and each supports certain codecs for audio and video compression.

MPEG is a family of compression algorithms, including MPEG-1, MPEG-2, and MPEG-4. MPEG Layer III Audio, commonly referred to as MP3, is a subset of the MPEG-1 specification. MP4 is an architecture designed to deliver all types of media over the Internet.

Document Everything

Create a detailed project specification and a master plan to track your progress. Write a script for the video prior to filming. Too much improvisation wastes time. Carefully prepared questions speed up an interview and improve the quality of responses. Make a master form for logging videotape footage with scenes, time code, and comments.

Perform Tests

Apply the complete production process from start to finish on a few sample clips. You may learn something later in the process that requires a change early in the process. For example, the face of a presenter may be too small when the movie is reduced to a lower resolution. Shooting up close would solve this problem, but it is not possible to shoot all the footage again. Play back samples of compressed video on your target devices, looking for dropped frames, issues with the audio track, or lack of synchronization between the audio and video tracks. Simulate the user's experience by uploading a clip and accessing it at the same data rate on the same device and connection they will use.

2. Shoot the Video

These recommendations are for creating movies that will compress well, since most of the loss in quality occurs during compression. The goal of shooting for compressed video is to produce a crisp video signal with the least noise, camera movement, and fine detail as possible so that the movie will look good in a small window. Before selecting a format, evaluate your options and the technical side of the process.

Different Video Formats

You may need to use archival content recorded in the U.S. standard NTSC format. This specification calls for a broadcast bandwidth of 4 MHz and a color subcarrier frequency of 3.58 MHz. It has 525 horizontal scan lines, 29.97 frames per second, and two fields per frame. These two fields alternate and are interlaced.

Assuming your content was all digitally captured, there is little reason at the time of this writing to be concerned about analog tape sources.

Spatial Resolution

The size of a video frame on your footage may not be the same as your intended delivery platform. Currently, the most common resolution for most video is 16x9 on smart phones, tablets, and monitors. If material comes from a source with a different aspect ratio, it will likely end up framed in a "letterbox," with black areas on each side.

Composite vs. Component

A composite signal, with color and light information combined on a single channel, contains a lot of video noise. This appears as "snow," or a dirty residue on the picture. The VHS format is composite by nature. The RCA connectors used to patch the video signal carry all of the information.
A component signal, with color and light separated, has less inherent noise. The S-video format provides for two channels, or Y/C video. Hi-8 and S-VHS tapes use this format. It is also the analog output signal from a DVCAM. The highest quality analog format is the three-part component (Y, R-Y, B-Y), which further divides the color spectrum into two channels. It was used in Betacam SP and other older formats.

Use the Best Available Camera

A high-quality original is the first important step towards a high-quality compressed movie. In addition to lower noise, professional cameras produce a sharper image and better colors with their superior optics and multichip design. If you know your video is going to be streamed from YouTube, Vimeo, or other popular servers, your process is greatly simplified by using a camera that shoots and compresses simultaneously in one of the preferred formats for these platforms. DV cameras are available that store several formats, including MP4 at various compression ratios as well as a raw, uncompressed version for editing and compressing later. Common types of cameras are described below:

Betacam SP (Professional) This is a tape format that will yield higher resolution and less noise most other analog cameras, with adequate color information for blue screen work. Since Betacam is an analog format, the output will need to be encoded for use in a digital editing system. There are libraries of analog content in this format.

MiniDV, DVCPro, and DVCAM (Pro-sumer) DV is a high-quality, digital format that integrates extremely well with desktop computers. The three formats of Digital Video (DV) are miniDV, DVCPro, and DVCAM. MiniDV is the most common and is generally used in consumer cameras. DVCPro and DVCAM are professional formats and are not as widely available. DV tapes are recorded with a slight degree of compression, similar to 5:1 Motion-JPEG. The DV format is far superior to Hi-8, S-VHS, and other consumer formats. DV is digital, so it does not suffer from generation loss as copies are made. A miniDV camera is easily connected to a computer with a Firewire card (IEEE-1394 specification), which Sony calls "i-Link." Most DV cameras offer a progressive scan feature, which records each frame as a single non-interlaced image instead of two separate interlaced fields. If you know the material will be compressed later, shoot in this format. The miniDV format uses 4:1:1 color subsampling, which is insufficient for high-quality blue screen work. The Panasonic DVCPro 50 format has higher color resolution, with 4:2:2 color subsampling. This means that the amount of color information is not reduced significantly.

Smart Phones Most phones as of this writing are capable of very high-quality video capture, some at 4K, most at 1080. However, when video files are compressed for transfer over networks they can be significantly degraded.

Light for Compression

Movies that are well-lit and have a low level of contrast between images will compress better than video shot with weak lighting. Low light conditions produce a grainy image that does not compress well. Compression makes this condition worse.

Use a Tripod and Minimize Motion

The use of a tripod often makes a dramatic impact in the quality of the final movie. Keeping the camera steady reduces subtle differences between frames, improving the temporal compression of the video. Any change in the image will cause the compressor to work harder. This applies both to camera movement and to subject movement. Use hard cuts instead of panning rapidly across a scene. Zoom slowly and only when necessary. Keep subjects as static as possible. The better cameras and phones have image stabilization that is quite effective. This feature is essential when shooting fast action, such as a sporting event or music video.

Minimize Detail

Keeping the detail within a scene to a minimum will help the video compress better spatially. It will also make the video easier to see when the movie is reduced to a smaller aspect ratio. Ask subjects to wear clothes that do not have high contrast patterns. Plain colors are best. Stripes and checked patterns can cause moire patterns when the video is resized and compressed. Keep the background plain for an interview. Painted backdrops are very good. Do not shoot in front of a window (to avoid reflections). You may wish to put the background out of focus to minimize detail. Bushes and trees are a particularly poor choice for the background because of the high degree of detail and motion.

Blue Screen

Shooting with a blue curtain or green background can improve the final results if you composite an actor into a digital still frame and “key” out the blue. The background has little video noise in it, and it compresses well. However, blue screen video is difficult to produce. One of the secrets to shooting good blue screen video, or “chroma key” is to light with slightly yellow gels or filters to improve the color spectrum. If it is not necessary to composite an actor over a different background, a painted backdrop is a simple effective option.

Record Clean Audio

The goal is to record a high-quality, noise-free audio signal with a strong level. Use remote microphones on a boom whenever possible to reduce camera noise. The internal microphone installed in a camcorder picks up excessive noise from the zoom motor. The operator who handles the camera also introduces noise. Minimize unnecessary noise in the audio signal such as wind and ambient sound. A wireless lavaliere microphone is ideal for recording a speaker’s voice.

3. Transfer or Capture the Video

The fastest way to move digital video files to a computer is by using a device that records to an SD card, and copying files from it. Alternatively, you can transfer the data from a DV camera using a USB3 cable, a thumb drive, or a Firewire interface. DV cameras already store their video in a digital format, so there is no need to encode. One convenient way to digitize analog video is simply to dub it from the tape format to a DV deck or camera. The digital capture operation is performed automatically, without the hazards of dropped frames and other problems that may be introduced. A raw video file may be as large as 20 megabytes for each running second. Many gigabytes of free space on the hard drive may be required for a video project. If possible, capture video directly from master tapes, not copies. Any second-generation tape will have more noise than the original master. If you want to capture selected cuts, note the time code for “In” and “Out” points, and use machine control to download the segments of your choice.

Monitor the Audio Track

Test the audio levels on a few clips before capturing your whole project. If the track is distorted, it will need to be recorded again and over-dubbed.

4. Edit and Add Effects

Video editing is an enjoyable and creative process. An editor combines segments of video, assembles them in order, and adds titles, transitions and effects. Adobe Premiere, Avid, and Final Cut Pro are some of the more widely used desktop editing applications. There are many other inexpensive programs available for video editing.

Basic Assembly

Many simple programs include the capability to assemble selected cuts into a larger movie. This is generally done by importing the desired segments of the original clips and arranging them in order, along a timeline, to create a new movie. You might choose to add some transitions between cuts, such as fades and wipes. When the assembly is complete with transitions, see that the audio track is synchronized with the video and shows strong levels. Title and save the final movie uncompressed and archive it. The final step will be to compress the movie.

Complex Edits

There are many editing programs that all produce sophisticated results. These programs feature a timeline-based interface that allows a user to put clips in order and apply transitions between the clips. There are many plug-ins made by third parties for Premiere to add special effects, transitions, and filters. Avid Cinema is one of the easiest editing packages to learn, but it lacks some of the advanced features of Premiere. Adobe AfterEffects allows a user to composite various layers of video and to create special effects with plug-ins. It is a powerful and complicated tool, the video equivalent of Photoshop in the graphics world.

Correct Video Problems Before Editing

Clips with shifts in color, gamma problems, and other problems that appear during shooting or capture should be repaired prior to editing. Ideally, all the clips that are assembled will conform to similar color and contrast levels.

Transitions

Like using too many different fonts in a document, it is a not wise to add too many elaborate transitions. They may be distracting to the viewer, and they pose problems in compression. Quick cuts from one scene to the next work well, as do quick cross-fades, keeping both to a minimum. It is possible to create a scene that zooms out from the center, spins, wraps around a cube, and flies away. Only in rare instances is this kind of "eye candy" appropriate to enhance or clarify the message. A simple cross-fade dissolve with a maximum one-second duration will compress well and can be used in just about any editing situation.

Edit and Render at High Resolution

Perform all editing and effects processing on uncompressed video at the highest resolution available. Do not resize the video with the editing software. Render, which means to output the final product, at the highest quality possible. If you input DV, render to the DV format with the same window size and audio sample rate to avoid losing quality.

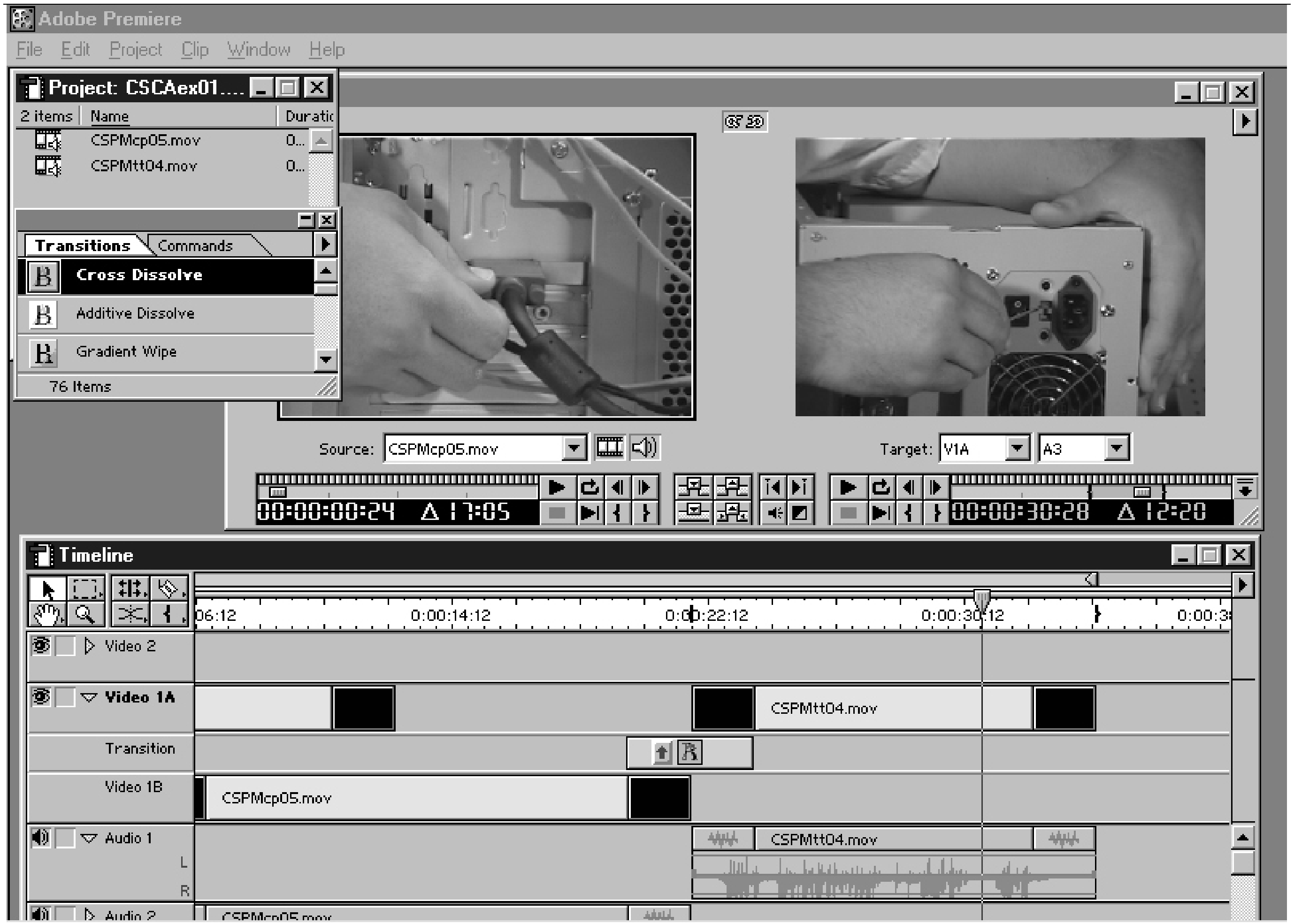

Figure 1 – Screen from Adobe Premiere editing window

Archive Formats

Save the edited file uncompressed or at least in the same resolution and size at which it was captured and edited. The Animation codec at 100 percent quality is a lossless software-only format. Plan to allocate lots of disk space for archiving this uncompressed, edited master file. If there is not enough space for the backup, a compromise is to use the Photo JPEG codec at 100 percent quality. This will compress it significantly, though some scenes may contain visible artifacts.

5. Compress the Video

Raw video is defined by more data than can be stored or transferred easily. Uncompressed full screen NTSC video requires about 27 megabytes of data for each running second. To arrive at this figure, multiply each frame (720 x 486) times 24 bits of color, times 30 frames per second.

Compression is a process that reduces the size of files by removing redundant data. Significant reduction is accomplished if some of the less critical data is also removed, which results in degraded images and sound, or lossy compression. Once data is thrown out during lossy compression, it can never be restored. A codec is an algorithm that both compresses and decompresses a media file, and the same codec must be applied at each end of the process. When selecting a codec to apply, a major consideration is whether the same version of the same codec will be previously installed on the target machine, or whether the viewer will be required to download and install a new codec to see the movie. At the time of this writing, the most common YouTube codec is H.264, but H.265 is more efficient and will eventually replace the H.264 standard.

How Codecs Work

Video is generally compressed with both spatial (interframe) and temporal (intraframe) techniques to remove redundant data. These are very different processes.

Spatial Compression: This method removes redundant data within a given image or frame. It operates primarily on areas of flat color with very similar pixels. The codec specifies the coordinates of the area and the color without great detail. Spatial compression also occurs when the JPEG algorithm is applied to a still graphic. Removing fine details before compressing can improve the spatial compression of an image. Video noise may appear to be fine detail to the codec and removing it will improve spatial compression. Shooting video with basic, still backgrounds leads to better compression.

Temporal Compression: In this method, the codec identifies only differences between consecutive frames and stores those differences rather than the entire image. The original reference frame from which the differences are calculated is called a keyframe. A keyframe in any video stream contains the complete image and may be used as an index point. Frames based on the differences between frames are delta frames. They define only the areas that are different from the previous frame and are smaller than keyframes. A new keyframe is placed at regular intervals to compensate for errors in delta frames.

Using a tripod when shooting reduces camera movement, providing a stable background that improves temporal compression. Avoiding complex transitions and frequent cuts that completely redraw the frame can contribute to smoother-looking compressed video.

Applying Codecs

A codec performs many mathematical calculations that generate each compressed frame, which may take several seconds. Later, the frame must be decompressed fast enough to play in real time at the established frame rate. An asymmetric codec takes longer to compress, but it decompresses without delay. Codecs used for live broadcasts and video teleconferencing must be symmetric, meaning they both compress and decompress in the same amount of time. The H.263 specification is a symmetric codec used for teleconferencing. When a media-viewing player such as Media Player or QuickTime is installed, all of the recent versions of both video and audio codecs are automatically installed on the computer

Comparison of Video Codecs

H.264 (MPEG-4) is a recommended codec for most users. It allows users to record in high speed, with a high compression ratio and quality. It is used on Blu-ray discs and some satellite TV broadcasts. The compression speed of hardware accelerated H.264 codec is comparable to Motion JPEG on high performing computers.

H.265 High-Efficiency Video Coding (HEVC) is being rapidly adopted at the time of this writing. It will compress files to half the size of H.264, or one-fourth the size of files compressed using the MPEG 2 codec used for most cable TV. HEVC is used to compress video with 4K resolution. The International Telecommunication Union (ITU) and the Moving Pictures Expert Group (MPEG), two standards organizations, developed HEVC. They also specified the MPEG-2 standard used in DVD, cable and other video formats, as well as the H.264 standard used in Blu-ray and high-definition online video.

XviD has gained popularity and is used in many devices and applications. Most CD/DVD players, Smartphones and media players support the Xvid codec. It is an open-source MPEG-4. codec.

MPEG-1 has been established as the most widely compatible lossy audio/video format in the world since the 1990's. Most media players and YouTube support the MPEG-1 codec. The MPEG-1 codec offers a good quality of video, similar to Xvid, and uses less processing power than other codecs. MPEG-1 files are somewhat smaller in size than Xvid.

MPEG-1 is a very efficient algorithm for creating highly compressed audio/video multiplexed files and was designed for playback at bit rates between 1 to 3 megabits per second. The native screen resolution of MPEG-1 is 352 x 240, which may be interpolated smoothly to double that size or resized to any resolution. The frame rate by default is 30 frames per second. The Fraunhoffer MPEG Audio Layer-3 codec is the de facto standard for MP3 audio-only files.

MPEG-2 is a higher-speed version of MPEG-1, designed for playback at bit rates between 6 to 15 megabits per second. This is faster than many aging computer systems can display smoothly without hardware assistance. It is the standard compressed video format for DVD movies, along with the Dolby AC-3 audio compression format used in the U.S. In Europe, the MPEG-2 audio compression format is more commonly used than AC-3.

Motion JPEG (M-JPEG or MJPEG) is a video format in which each video frame is a JPEG image, or a keyframe. Motion JPEG is a good choice if you are editing the video later.

YV12 is a lossless video codec of very high quality, better than MPEG-1 or XVID because YV12 files are not compressed. File sizes are much larger than MPEG-1 or XVID, but smaller than RGB24.

RGB24 is the highest quality video codec. The file is uncompressed, and therefore lossless. It yields the largest file size and may be impractical unless vast amounts of data storage are available.

Comparison of audio codecs

Advanced Audio Coding (AAC) is a lossy audio compression format and it generally offers higher-quality sound than an MP3 with a similar file size. Most video editing programs such as Adobe Premiere support the AAC audio codec.

MPEG-1 Audio Layer-3 (MP3) is a lossy audio compression format, and it is a universal standard. Most media players and YouTube support the MP3 audio format. It features a variable compression rate and small file size.

Pulse-code modulation (PCM) is a lossless audio compression format, and it is a standard format for digital audio in computers and various Blu-ray, Compact Disc and DVD formats. Use it for editing prior to compression for the highest audio quality.

Processing to Improve Compression

Several factors contribute to the apparent quality of a digital video. Among those that are easily improved with software are the contrast, black and white levels, hue and saturation, and undesirable video noise. One of the first steps to perform before compressing is to crop the video frame to eliminate any edge noise or black borders. Sophisticated software can be used to scale the image to your target resolution.

Color and Contrast

Most video segments can be improved for desktop delivery by increasing the contrast by 10 or 15 percent, which appears to remove a thick residue from the video screen. It is also a good idea to restore black areas to true black, using the Black Restore feature. Perform a similar operation to restore white areas, improving image quality and compression. The video may be improved by carefully adjusting the brightness or gamma in small increments. After selecting settings for these adjustments, scrub through the video looking for scenes in which the changes introduced may be unnatural or too severe.

Noise Reduction

Much better spatial compression is achieved if the granular detail in an image is reduced. Video noise appears to the compressor as though it were fine details that should be retained. A blur filter can be applied to reduce the noise and improve compression, but the final result will be less crisp. An adaptive noise reduction filter blurs areas of low contrast, but leaves edges sharp, improving the compressed result. Most live video will benefit from this filter.

Selecting Compression Settings

When choosing the settings for a compressed video file, the most important decisions to be made are which codec to use, the size of the video window (screen resolution), the frame rate, the data rate, and the frequency of keyframes. There are limiting factors and trade-offs involved with each choice, and they are usually based on the way in which the audience will access the video files.

There are several different types of audiences for digital video. In one case, the producer is able to specify and configure the exact system on which the video will be viewed, such as in a kiosk or on a corporate intranet. In another case, the general public is the audience and the minimum system requirements for viewing the video will be rather low. Within these categories, there is the option to distribute the video locally, from a DVD or other media, or to deliver it over a network. The latter choice limits the data rate and frame rate in most cases and negatively impacts the quality of the video experience.

Selecting a Video Codec

The choice of codec is in some cases dependent on the native format used by the capture device or video camera. If you use a device that captures in the MP4 format with ACC audio, it will integrate seamlessly with the You Tube platform. If you capture at higher resolution, a broad set of options exists. Quality is improved considerably if variable bit rate encoding is used. The implementation of codecs has become transparent to most users, but it is an issue to be aware of when you shoot video in one format and need to convert it to a more highly compressed format. Fortunately, there are several software packages available that convert to and from all the major formats. Audio codecs will be determined by the quality of sound desired, the bandwidth, and the target user platform.

Selecting the Data Rate

The data rate, or bit rate, is the most important factor in determining the quality of compressed video. It determines the file size and must be matched to the method of delivery that is specified for the video.

The factors that contribute to the data rate requirements are the broadband network speed available to the user, the amount of storage space available, and the configuration of the target device for playback.

Here are some data rate guidelines. It will be necessary to test playback under various conditions to determine the optimal rate.

CD-ROM: This device is at the low end of the delivery spectrum. A data rate of 250 to 300 kilobytes per second (KBps) is a conservative rate for cross-platform 4x-speed CD-ROM. The ability of an aging computer video system to redraw the screen may be a more important factor than the transfer speed of the drive.

DVD-ROM: Transfer speeds are usually equivalent to an 8X-speed CD-ROM, approximately 1 megabyte per second. A DVD-R holds about 4.7 gigabytes of data. Four gigabytes of data can contain several hours of high-quality video.

Internet: The type of connection and the volume of traffic impact potential throughput. It may be advisable to compress a video at several different rates for different connection speeds. For ISDN, keep it under 12 KBps; and for a T1 line, limit the rate to about 20 KBps. This accounts for all of the overhead that the Internet introduces, including error correction in the HTTP protocol.

Local Area Network (LAN): A high-speed LAN should be able to transfer video at around 30 to 60 KBps. These are conservative bit rates to avoid any dropped frames.

Router Transfer Rates vs. Video Bit Rates

At the time of this writing, most video is delivered by a WIFI modem and router if a direct fiber optic system is not employed over cable. The capacity of the router to deliver a continuous stream of data to multiple devices is a key factor in determining the quality and consistency of the video. The data transfer rate of the end-to-end delivery system is a critical factor to consider along with your video data rate to project the end-user experience.

Selecting the Frame Rate

The frame rate is the number of times per second the playback device completely redraws the video window. A high frame rate requires a high-speed connection if the video is streamed over the Internet. Frame rates for video typically range from 12 to 30 frames per second (fps), and up to 60 fps. Motion appears relatively smooth at about 15 frames per second. For reference, film is shot at 24 fps, PAL video at 25 fps, and NTSC video at slightly under 30 fps (29.97). Choosing the frame rate that seems to suit the content is rather subjective. At a given bit rate, a low frame rate will produce sharper images but jerky motion. At the same bit rate, a high frame rate produces blurred images but smoother motion. There is always a trade-off in selecting the frame rate for a given bit rate. The best way to select the frame rate is to test several options for the best compromise between clarity and smoothness. A frame rate that is an even divisor of the source frame rate usually yields best results. For NTSC video, use 30, 15, or 10 fps. For PAL video use 25 or 12.5 fps, and for film use 24 or 12 fps.

Selecting the Size of the Video Window

With current playback software that smoothly resizes a window, this is not such a significant concern. However, the original window size and frame rate remain a constant factor defining the video content. If you expect most users to access the video in a 16x9 window, or HD format, that is a good starting point.

If, on the other hand, you want to constrain the window size for a pop-up or video overlay, you might go with a 4x3 aspect ratio. A number of factors must be considered in making this decision, most importantly the nature of the content itself and the degree of detail that needs to be clearly displayed. A talking head that fills the window may be effective at a small window size, such as 240 x 180. However, a training video demonstrating the performance of a process that requires detail may need to be shown at 320 x 240 or larger. Resizing the window to a much larger size than the original will result in degraded image quality. Some video processors are able to "interpolate" a double-sized image from the original with better results than are achieved by an arbitrary size that is not an exact multiple of the original.

Other factors to consider in determining the optimal window size are the nature of the content, the data rate, the frame rate, the codec, and the target device. Changing any one of these factors may impact the others.

Selecting a Keyframe Rate

Each keyframe completely defines the image in the frame, while delta frames are approximations based on the best guesses that the compression engine can make. Much more data is required to define each keyframe than the frames between them. It is important to have enough keyframes to support changes in the video scenes and maintain the integrity of images while avoiding unnecessary keyframes that merely add bulk to the size of the video. A keyframe every 150 frames for video running at 15 fps is usually adequate. If a user will randomly access points in the video, more frequent keyframes may improve the experience.

Adjusting Settings in Compressing Video

The real power of a video editing and compression tool lies in the ways in which a producer can process a video. You can experiment with increasing the brightness and contrast of a clip. Historically, Windows display gamma is different from Mac OS gamma, and video may appear darker in Windows at the same gamma setting. You may try setting the gamma lower when working in Windows. Also, vary the Hue and Saturation settings to see the results. Test variations in the Black restore and the White restore features to achieve more consistent levels.

Selections you can make to compress the video usually include the codec, the frame rate, keyframe frequency, and the bit rate. Variable Bit Rate (VBR) encoding can greatly improve the final product. The movie may also be constrained to a specified data rate. You may have an option to apply filters that Blur or Sharpen the video, or to use a Flat Field Adaptive Noise Reduction filter. Selections to compress the audio include the codec, the sample rate, the bit depth, and data rate. Mono is often chosen over stereo since it consumes half the space and requires half the bandwidth, but current YouTube files can stream stereo audio if you have the bandwidth. There is often an option to Normalize the audio. Normalizing an audio track will raise all levels relative to a preset point, effectively accomplishing compression between higher and lower dynamic levels. Among the other audio processing options are High and Low Filters and Noise Removal. It is best not to be too aggressive with any of these processes, which can significantly alter the sound quality. Audition your audio edits in a non-destructive environment, so that changes can be reversed.

It may be best to preview the processes applied to a video clip to see the results first, before compressing. This may speed up the time it takes to perform the compression. Click on the "Start" button to apply any of the operations chosen in the settings. Cleaner will prompt for a destination for the final files before processing. Historically, QuickTime movies needed to be "flattened" to play in the

Windows environment if they were created in the Mac OS. To flatten a movie is to remove the Macintosh headers from the data stream and apply the .mov extension. This may be done transparently by your cross-platform software.

6. Prepare for Distribution

The two primary options for distribution are removable media and network delivery. The processes and data structures for creating a DVD are well documented. There are variables involved in streaming video, since the Internet is a packet-driven network. HTTP was not originally intended to stream data continuously, but rather to move small, discrete packets of data from place to place. The route through which data is passed and the transfer rate are both variables. With faster connections and the Real Time Streaming Protocol (RTSP), streaming media over the Internet is possible, but it still is not as reliable as delivery from a dedicated video server. A dedicated server is used to store multimedia files and video streams. The content is delivered via a Content Delivery Network (CDN) that compresses data and delivers it in small chunks to reduce lag and prevent overload. Rather than downloading the content locally in order to view it, viewers can watch it on-demand from the browser.

Streaming Video on the Web

This could involve building HTML pages that contain pointers to the video files on the server and placing audio and video files on the server using file transfer protocol (FTP). The <EMBED> tag is used to link a compressed video file to an HTML document. Some HTML WYSIWYG editors automate this process by creating the <EMBED> tags ready to paste into a web page. An audio file can also be embedded to provide a soundtrack for a web page.

However, most developers simply upload their video files to YouTube, Vimeo, or some dedicated video streaming provider and link to the location of their files.

The Future of Digital Video

Broadcast networks and on-demand services have generally maintained a professional level of production quality, given the move from analog film to digital video formats. They have given viewers an almost unlimited array of options. With the proliferation of DV camcorders and smart phones, the amount of video streaming on the Internet will continue to increase exponentially. Improved technology for creating amateur video in the hands of novices has led to relatively low production quality for videos commonly attached to email messages and texts. This Production Guide will hopefully provide tools and formation for those who wish to improve the quality of their productions and take on larger creative projects.

It will be interesting to see how the Internet community addresses the incredible demand for bandwidth and storage capacity that digital video introduces, how commercial models evolve, and issues of copyright ownership. Compressed video will continue to have a significant impact on education and training, as well as on business and personal communications. This, in turn, will influence how we humans think about the art of communication itself.

