Video

Chapter 7

What is Video?

- Video is when you take many pictures per second, sequence the pictures in order, and play them back at about the same rate as they were taken.
- Animation is different.
  - Typically, you take or make the pictures at a much slower rate but then play them back at a faster rate.
  - Not live, not real-time.

Video Recording

- The technology for recording video is pretty much the same as the technology for taking pictures
  - Optical device that can capture a scene (the actual light) and store it.
- How to store it
  - Negative film (analog)
  - Digital encoding (requires codec)
- The challenge is that video requires taking and storing many picture per second.

Movie Cameras vs. Camcorder

Movie Cameras stores images on negative film.

- Mechanical – moving parts
- Optical – glass lenses
- Analog – no bits needed

Camcorder stores images on magnetic tape.

- Still mechanical – to move tape
- Same optical technology as any camera
- Analog capture but images stored digitally (requires a codec).

Analog vs. Digital

- Q: Are camcorders analog or digital?
- A: They are both
- They process analog signals (light and sound waves)
- At some point the signals are digitally encoded.
- Magnetic Tapes → Bit encoding
- Negative Film → No bits, real image

Alternative to Magnetic Tapes

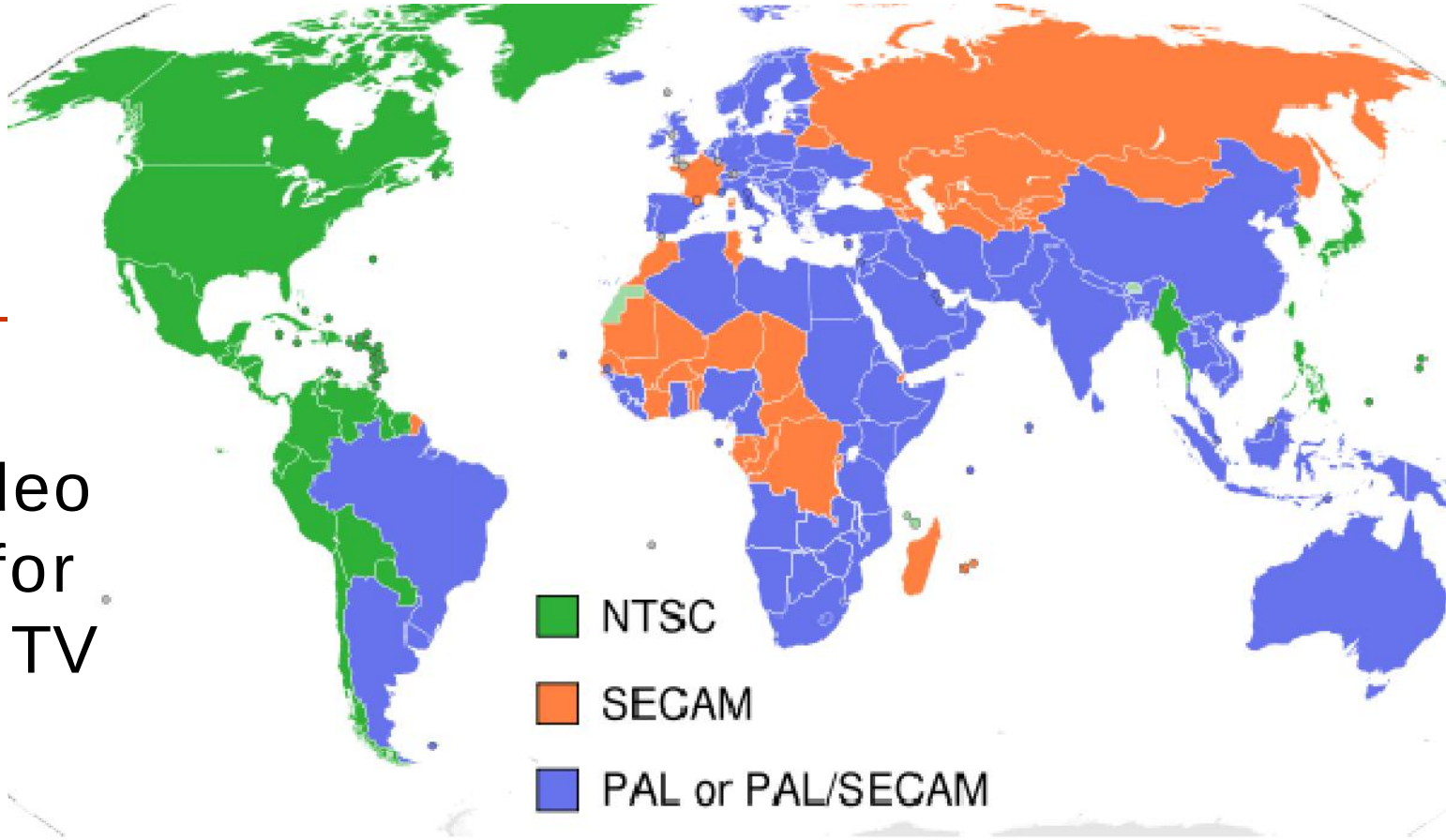
- As Flash memory chips get bigger, they will likely replace tapes.
- Also, camcorders may eventually have Hard Disks similar to the 20GB+ iPods.
- Tapes are still more cost effective for recording/archiving.
- Tapes are sequential, no random access.

Recording is driven by Broadcast

- The way video is recorded/stored is dictated by how it is Broadcast.
  - Specifically, TV Broadcast
- Broadcast refers to how the signal is transmitted to the masses.
- Ultimately, dictated by
  - What kind of TV's people have
  - Cable TV systems

PAL

- Is an Analog Video Standard for Broadcast TV



- Phase Alternating Line is a color encoding system used in broadcast television in large parts of the world (Most of Europe)
- Other common television systems are SECAM and NTSC.

NTSC

- National Television System Committee
- Analog television system used in USA, Canada, Japan, Mexico, the Philippines, South Korea, and Taiwan.

PAL (Digital Specifications)

- Minimal Resolution
  - 768x576 pixels per frame
    - x 3 bytes per pixel (24 bit colour)
- Minimal Sampling
  - x 25 frames per second
- Uncompressed Size
  - ≈ 31 MB per second
  - ≈ 1.85 GB per minute
- Compressed Size

NTSC (Digital Specifications)

- Minimal Resolution
  - 640x480 pixels per frame
    - x 3 bytes per pixel (24 bit colour)
- Minimal Sampling
  - x 30 frames per second (approx)
- Uncompressed Size
  - ≈ 26 MB per second
  - ≈ 1.6 GB per minute
- Compressed Size
  - ≈ 4 MB per minute
  - ≈ 240 MB per minute

Camcorders revised…

- The term camcorder is combination of
  - Camera + Tape Recorder
- VHS and Beta were the initial standard
  - VHS won.
  - Similar to Blu-ray vs. HD DVD
- Long before VHS recorders were marketed to the end consumer
- VHS camcorders and devices were pioneered by the TV news market.

The New Camcorders

DV and MiniDV - Same thing as VHS but

- Physically smaller tape
  - Recorders are smaller
- More storage capacity
  - Higher resolution video
- Faster encoding
  - More frames per second
  - Less noise

DV and MiniDV

- Intended for consumer market as a high-quality replacement for VHS Camcorders
- But, L-size DV cassettes are primarily used in professional settings
  - Standard for TV News
- Mini DV Camcorders are becoming consumer standard.
- I requested a MiniDV for this course but was denied.

DV and MiniDV

- The "L" cassette
  - 4.6 hours of video
- The better known MiniDV "S" cassettes
  - 60 or 90 minutes of video (11 GB)
- Terminology
  - Standard Play (SP)
  - Extended Play (sometimes called Long Play) (EP/LP).
- Mini-DV Tapes are about $3.00 each

DVCPRO

- Panasonic created DVCPRO for electronic news gathering.
  - Higher resolution and more frames per second compared to DV standard
  - Better linear editing capabilities and robustness.

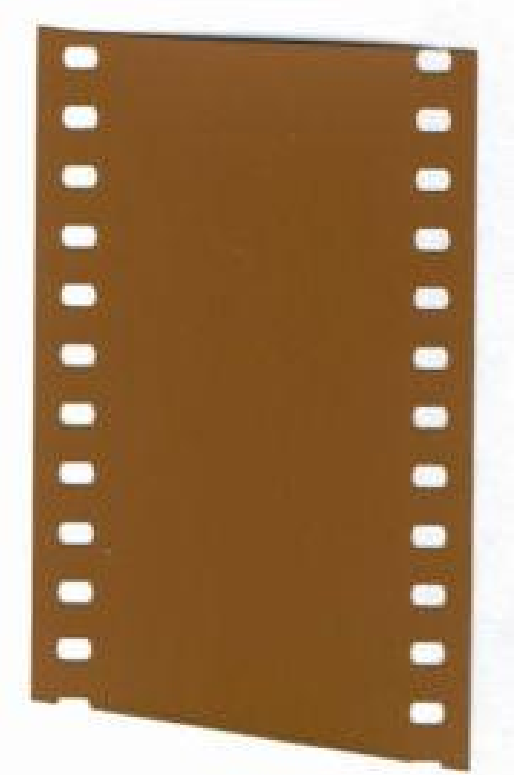
- DVCPRO HD, also known as DVCPRO100 can capture video at 1440x1080 up to 60 frame per second.
- "M" tape can only hold up to 66 minutes of video.

HD Digital Movies

- Most major motion pictures are shot in negative film (analog technology)
- Film negative is high resolving medium (as good as the best digital capturing technology)
  - Academy camera US Widescreen:
    - 21 × 11 mm → 2970 × 1605
  - Current Anamorphic Panavision ("Scope"):
    - 21 × 17.5 mm → 2970 × 2485
  - Super-35 for Anamorphic prints:
    - 24 x 10 mm → 3390 × 1420

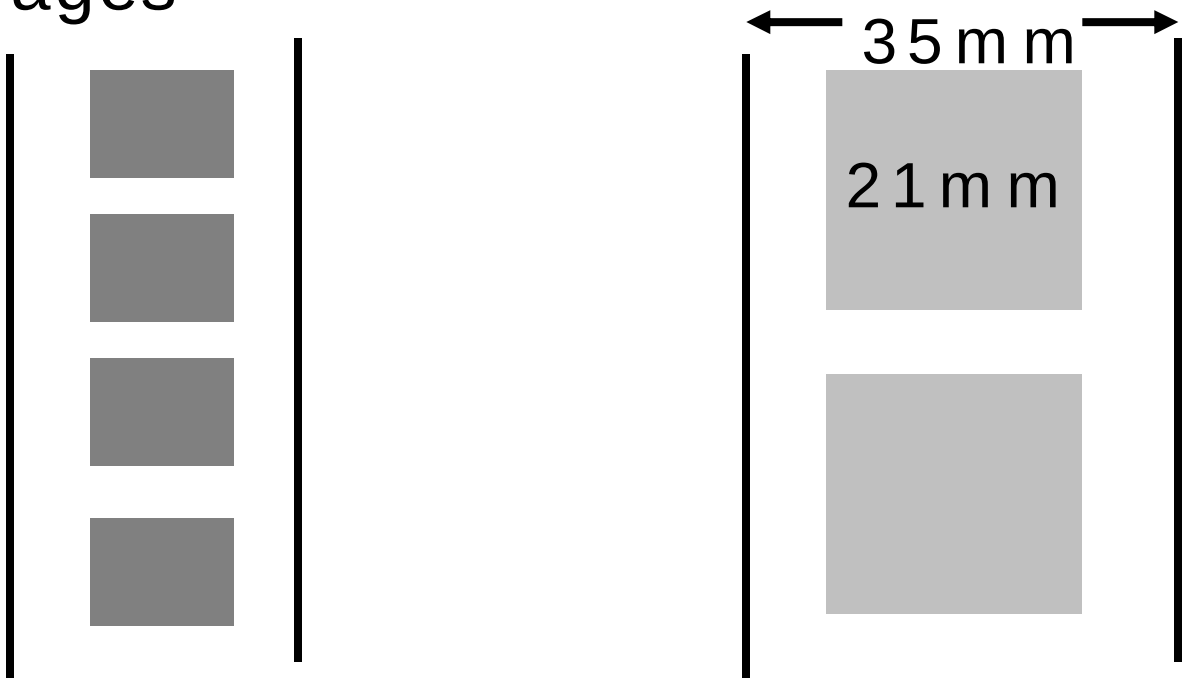
How Film Works

- Film has millions of light-sensitive silver halide crystals (silver + halogen)
  - held together in a cubical arrangement by electrical attraction.
- When crystals are struck by light, silver ions build up a collection of uncharged atoms.
- These ions, too small to even be visible under a microscope, are the beginning of a latent image.
- Developing chemicals use the latent image specs to build up density, an accumulation of enough metallic silver to create a visible image



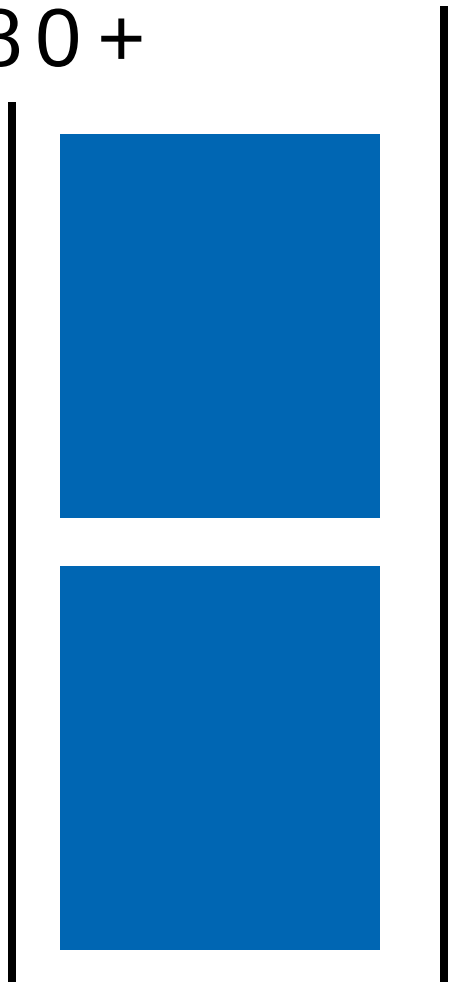
Film Width

- Each image stored sequentially on film role.
- To achieve higher resolution, you can increase the width of the film
- Only part of the width can be used to capture images



Film Width & Orientation

- 35mm Film can achieve High Definite (HD) resolutions
- HD Wide Screen 1920+ × 1080+
- 70mm can go way beyond the HD seen on BluRay and HD DVD.
- IMAX used 70mm film and changes the orientation.
- 10000 X 7000 is possible.



Digitizing Film

- Converting the Film (analog) to digital form.
- Negative Film Scanners are used...
- Prices range from $100 to $20,000
- http://www.ephotozine.com/article/Plustek-OpticFilm-7200i

Recap

- Video standards are driven by what can be viewed or Broadcast.
  - Broadcast standard in US is NTSC 640 X 480.
- Magnet Tape is still the most cost-effective technology for storing digital video.
- Improvements in viewing Technology: Affordable HD TV's, DVD's, Bluray, etc. have lead to…
  - DV, MiniDV, and DVCPro recorders and tapes
  - DVCPro HD → 1440x1080

Recap

- Negative Film (analog) is still superior to digital alternatives in terms of
  - Maximum Resolution
  - Frame rate
- However, for production, negative film is often digitized using film scanners.
  - Digital video is easier to edit.
  - Digital signals have no noise.
    - Analog signals can be corrupted when transmitted over distances. Negative film can also be easily damaged.

Another example of Multimedia

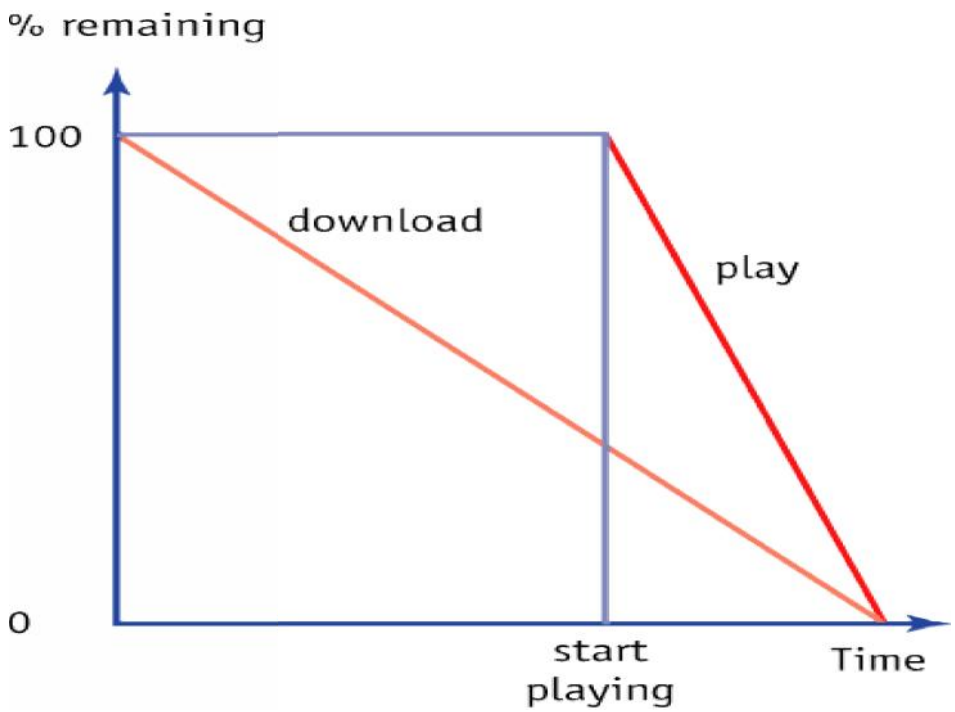
- http://www.cia.edu/dreams/surreal/index1.html

Streamed Video

- Play back a video stream as it arrives over a network (like broadcast TV), instead of downloading an entire video clip and playing it from disk (like renting a DVD)
- Example: youTube

HTTP Streaming

- Start playing a downloaded clip as soon as enough of it has arrived
- Starts when the (estimated) time to download the rest is equal to the duration of the clip



Ideal Streaming Systems

- Ideally, several different versions could be available
- Your system (web browser, etc.) download that largest version that it can play in real-time.
  - Starts immediately
  - Downloads entirely before its over
- Requires knowledge of you network performance, which could change
- Pipe Dream of sorts.

Interlacing

- Required for TV signal; Capitalizes on features of CRT technology.
- Each frame is divided into two fields
- Field 1: odd lines; Field 2: even lines
- Fields are transmitted one after the other
- Frame is built out of the interlaced fields
- http://en.wikipedia.org/wiki/Interlace

Chrominance

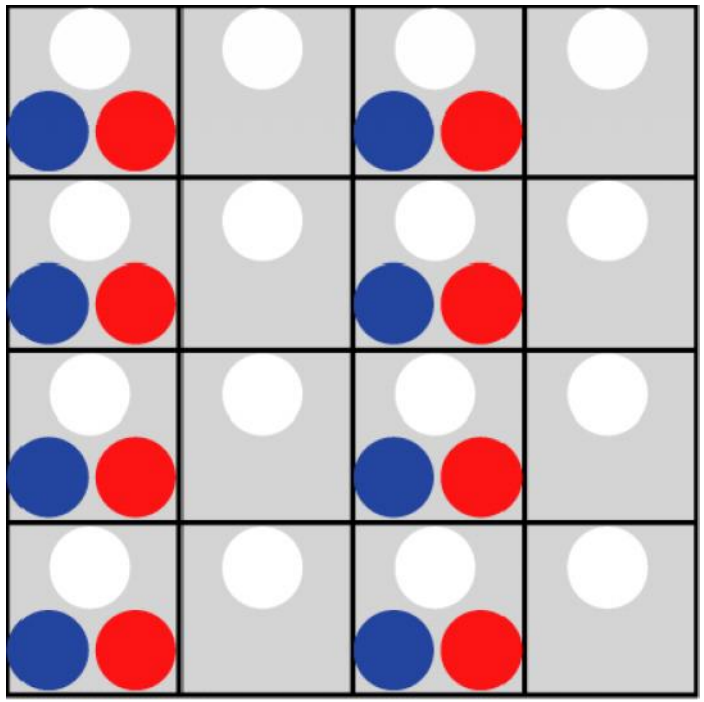
- Chrominance (chroma for short), is the signal used to carry the color information separately from the accompanying luma signal.
  - Chroma is color
  - Luma is brightness
- Chrominance has two color difference components:
  - B'–Y' (blue – luma)
  - R'–Y' (red – luma)

Chrominance

- Separating RGB color signals into luma and chroma values has many advantages
- First, in B&W CRT's can display only the luma values, which gives you the gray-scale component.
- Second, the human eye is more sensitive to luma then chroma, so you don't have to transmit the chroma signal for all pixels.

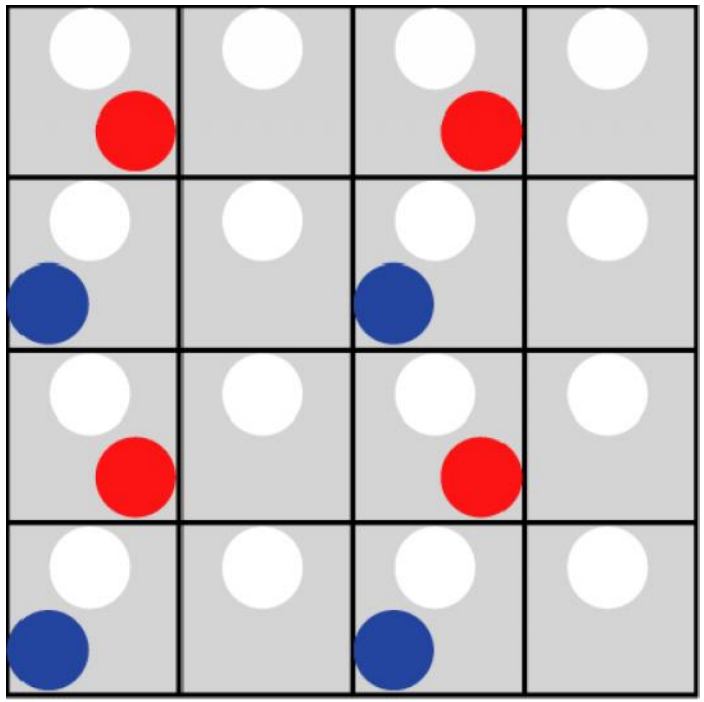
4:2:2 sub-sampling

- Twice as many luma samples as each of chroma samples
- Normally, there would be three signals (dots) for every pixel.
- How, many dots per pixel are here? (on averge).



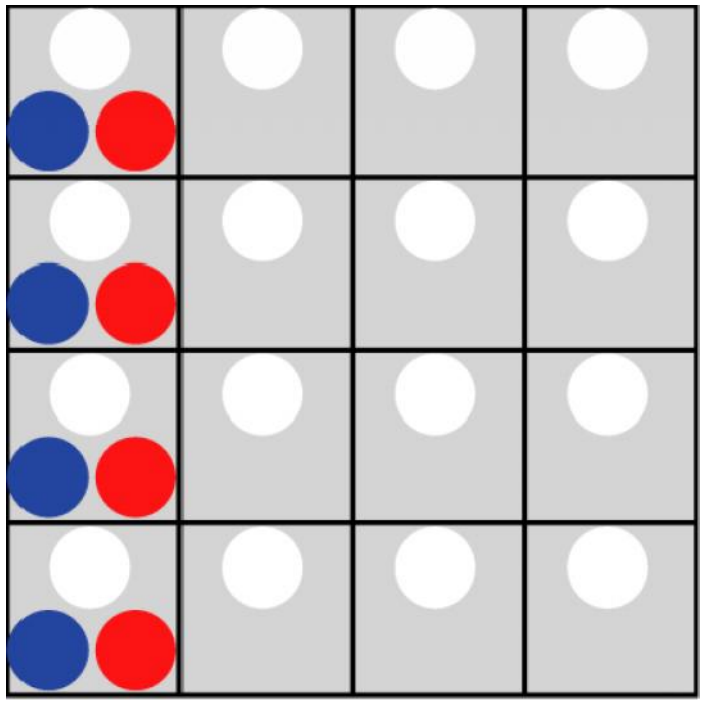
DV sub-sampling

- PAL DV 4:2:0 chrominance sub-sampling



DV sub-sampling

- NTSC DV 4:1:1 chrominance sub-sampling



MPEG

- ISO/IEC Motion Picture Experts Group
- Series of standards including
  - MPEG-1 intended for video CD
  - MPEG-2 used in DVD and broadcast
  - MPEG-4 for low bitrate multimedia

MPEG Profiles & Levels

- Profiles define subsets of the features of the data stream
- Levels define parameters such as frame size and data rate
- Each profile may be implemented at one or more levels
- Notation: profile@level, e.g. MP@ML
- http://en.wikipedia.org/wiki/MPEG-4_Part_2#Profiles

MPEG-2 Profiles & Levels

- MPEG-2 Main Profile at Main Level (MP@ML) used for DVD video
  - CCIR 601 scanning ← Interlaced
  - 4:2:0 chrominance sub-sampling
  - 15 Mbits per second

MPEG-4

- Designed to support a range of multimedia data at bit rates from 10kbps to >1.8Mbps
- Applications from mobile phones to HDTV
- Video codec becoming popular for Internet use, is incorporated in QuickTime, RealMedia and DivX

MPEG-4 Profiles & Levels

- Visual Simple Profile (SP), suitable for low bandwidth streaming over Internet
- Visual Advanced Simple Profile (ASP) suitable for broadband streaming
- SP@L1 (Level 1 of Simple Profile), 64 kbps, 176x144 pixel frame
- ASP@L5, 8000 kbps, full CCIR 601 frame

Video Compression

- Spatial (intra-frame) compression
  - Compress each frame in isolation, treating it as a bitmapped image
- Temporal (inter-frame) compression
  - Compress sequences of frames by only storing differences between them
- Always some compression because of sub-sampling

Spatial Compression

- Image compression applied to each frame
- Can therefore be lossless or lossy, but lossless rarely produces sufficiently high compression ratios for volume of data
- Lossless compression implies a loss of quality if decompressed then recompressed
- Ideally, work with uncompressed video during post-production

Temporal Compression

- Key frames are spatially compressed only
  - Key frames often regularly spaced (e.g. every 12 frames)
- Difference frames only store the differences between the frame and the preceding frame or most recent key frame
- Difference frames can be efficiently spatially compressed

Motion JPEG

- Purely spatial compression
- Apply JPEG to each frame
- Used by most analogue capture cards
- No standard, but MJPEG-A format widely supported

DV Compression

- Starts with chrominance sub-sampling of CCIR 601 frame
- Constant data rate 25Mbits per second
- Higher quality than MJPEG at same rate
- Apply DCT, quantization, run-length and Huffman coding on zig-zag sequence – like JPEG – to 8x8 blocks of pixels

DV Compression

- If little or no difference between fields (almost static frame), apply DCT to block containing alternate lines from odd and even fields
- If motion between fields, apply DCT to two 8x4 blocks (one from each field) separately, leading to more efficient compression of frames with motion

DV Compression

- Shuffling
  - Construct video segments by taking 8x8 blocks from five different areas of the frame, to ‘average’ amount of detail
  - Calculate coefficients for whole video segment, making more efficient use of available bytes

Older Codecs

- Cinepak – Longest established, high compression ratio, takes much longer to compress than to decompress
- Intel Indeo – Similar to Cinepak, but roughly 30% faster compression
- Sorenson – More recent, higher quality and better compression ratios than other two
- All three based on vector quantization
- Quality of all three inferior to MPEG-4

Vector Quantization

- Divide each frame into small rectangular blocks (’vectors’)
- Code Book – collection of constant vectors representing typical patterns (edges, textures, flat colour,...)
- Compress by replacing each vector in image by index of vector from code book that most closely resembles it

Post-Production

- Changing or adding to the material
  - Most changes are generalizations of image manipulation operations (e.g. colour correction, blurring and sharpening,...)
- Compositing – combining elements from different shots into a composite sequence
- Animating elements and combining animation with live action

Preparing for Delivery

- Compromises required to bring resource requirements of video within capabilities of delivery media (e.g. networks) and low-end machines
  - Reduce frame size (e.g. downsample to quarter frame)
  - Reduce frame rate (12fps is OK for smooth motion, flicker not a problem on computer)
  - Reduce colour depth