Basics of Video

Multimedia Systems (Module 1 Lesson 3)

Summary:

- Types of Video
- Analog vs. Digital Video
- Digital Video
  - Chroma Sub-sampling
  - HDTV std.
- Computer Video formats

Sources:

- My research notes
- Conventional Analog Television Dr. Kelin J. Kuhn
  http://www.ee.washington.edu/conselec/CE/kuhn/ntsc/95x4.htm
- Dr. Ze-Nian Li's course material at:
  http://www.cs.sfu.ca/CourseCentral/365/li/

Types of Video Signals

- *Component video* -- each primary is sent as a separate video signal.
  - The primaries can either be RGB or a luminance-chrominance transformation of them (e.g., YIQ, YUV).
  - Best color reproduction
  - Requires more bandwidth and good synchronization of the three components
- *Composite video* -- color (chrominance) and luminance signals are mixed into a single carrier wave.
  - Some interference between the two signals is inevitable.
- *S-Video* (Separated video, e.g., in S-VHS) -- a compromise between component analog video and the composite video. It uses two lines, one for luminance and another for composite chrominance signal.

Analog Video

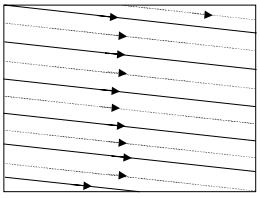
Analog video is represented as a continuous (time varying) signal;
Digital video is represented as a sequence of digital images

NTSC Video

- 525 scan lines per frame, 30 fps (33.37 msec/frame).
- Interlaced, each frame is divided into 2 fields, 262.5 lines/field
- 20 lines reserved for control information at the beginning of each field
- So a maximum of 485 lines of visible data
  - Laserdisc and S-VHS have actual resolution of ~420 lines
  - Ordinary TV -- ~320 lines
  - Each line takes 63.5 microseconds to scan.
- Color representation:
  - Uses YIQ color model.

PAL (SECAM) Video

- 625 scan lines per frame, 25 frames per second (40 msec/frame)
- Interlaced, each frame is divided into 2 fields, 312.5 lines/field
- Color representation:
  - Uses YUV color model



Frame Rate and Interlacing

- *Persistence of vision:* The human eye retains an image for a fraction of a second after it views the image. This property is essential to all visual display technologies.
  - The basic idea is quite simple, single still frames are presented at a high enough rate so that persistence of vision integrates these still frames into motion.
- Motion pictures originally set the frame rate at 16 frames per second. This was rapidly found to be unacceptable and the frame rate was increased to 24 frames per second. In Europe, this was changed to 25 frames per second, as the European power line frequency is 50 Hz.
- When NTSC television standards were introduced, the frame rate was set at 30 Hz (1/2 the 60 Hz line frequency). Movies filmed at 24 frames per second are simply converted to 30 frames per second on television broadcasting.

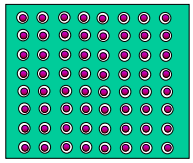
Frame Rate and Interlacing

- For some reason, the brighter the still image presented to the viewer, the shorter the persistence of vision. So, bright pictures require more frequent repetition.
- If the space between pictures is longer than the period of persistence of vision -- then the image flickers. Large bright theater projectors avoid this problem by placing rotating shutters in front of the image in order to increase the repetition rate by a factor of 2 (to 48) or three (to 72) without changing the actual images.
  - Unfortunately, there is no easy way to "put a shutter" in front of a television broadcast! Therefore, to arrange for two "flashes" per frame, the flashes are created by ***interlacing***.
- With interlacing, the number of "flashes" per frame is two, and the field rate is double the frame rate. Thus, NTSC systems have a field rate of 59.94 Hz and PAL/SECAM systems a field rate of 50 Hz.

Digital Video

- *Advantages over analog:*
  - Direct random access --> good for nonlinear video editing
  - No problem for repeated recording
  - No need for blanking and sync pulse
- Almost all digital video uses *component video*
- The human eye responds more precisely to brightness information than it does to color, *chroma subsampling* (*decimating*) takes advantage of this.
  - In a 4:4:4 scheme, each 8×8 matrix of RGB pixels converts to three YCrCb 8×8 matrices: one for luminance (Y) and one for each of the two chrominance bands (Cr and Cb).
  - A 4:2:2 scheme also creates one 8×8 luminance matrix but decimates every two horizontal pixels to create each chrominance-matrix entry. Thus reducing the amount of data to 2/3^{rds} of a 4:4:4 scheme.
  - Ratios of 4:2:0 decimate chrominance both horizontally and vertically, resulting in four Y, one Cr, and one Cb 8×8 matrix for every four 8×8 pixel-matrix sources. This conversion creates half the data required in a 4:4:4 chroma ratio.

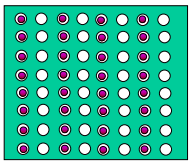
Chroma Subsampling(…contd.)



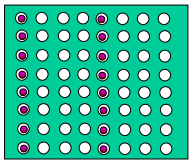
8x8 : 8x8 : 8x8

4 : 4 : 4

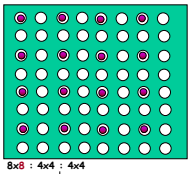
- 4:1:1 and 4:2:0 are used in JPEG and MPEG
- 256-level gray-scale JPEG images aren't usually much smaller than their 24-bit color counterparts, because most JPEG implementations aggressively subsample the color information. Color data therefore represents a small percentage of the total file size.



8x8 : 8x4 : 8x4 → 4 : 2 : 2



8x8 : 8x2 : 8x2 → 4 : 1 : 1



8x8 : 4x4 : 4x4

8x8 : 8x2 : 0x0 → 4 : 2 : 0

HDTV

Name	Lines	Aspect Ratio	Opt. View dist	P/I	Freq. MHz
HDTV USA, ana	1050	16:9	2.5H	P	8
HDTV Eur, ana	1250	16:9	2.4	P	9
HDTV NHK	1125	16:9	3.3	I	20
NTSC©	525	4:3	7	I	4.2
NTSC	525	4:3	5	P	4.2
PAL©	625	4:3	6	I	5.5
PAL	625	4:3	4.3	P	5.5
SECAM©	625	4:3	6	I	6
SECAM	625	4:3	4.3	P	6

©: Conventional

Computer Video Format

- Depends on the i/p and o/p devices (digitizers) for motion video medium.
- Digitizers differ in *frame resolution, quantization and frame rate*
  - IRIS video board VINO takes NTSC video signal and after digitization can achieve frame resolution of 640x480 pixels, 8 bits/pixel and 4 fps.
  - SunVideo digitizer captures NTSC video signal in the form of an RGB signal with frame resolution of 320x240 pixels, 8 bits/pixel and 30 fps.

Computer video controller standards

- The *Color Graphics Adapter (CGA):*
  320 x 240 pixels x 2 bits/pixel = 16,000 bytes (storage capacity per image)
- The *Enhanced Graphics Adapter (EGA):*
  640 x 350 pixels x 4 bits/pixel = 112,000 bytes
- The *Video Graphics Array (VGA):*
  640 x 480 pixels x 8 bits/pixel = 307,200 bytes
- The *8514/A Display Adapter Mode:*
  1024 x 768 pixels x 8 bits/pixel = 786,432 bytes
- The *Extended Graphics Array (XGA):*
  1024x768 at 256 colors or 640x480 at 65,000 colors
- The *Super VGA (SVGS):*
  Upto 1024x768 pixels x 24 bits/pixel = 2,359,296 bytes