Video Introduction

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  - Colour space representations
  - Digitisation (sampling)

NTSC (National Television Standards Committee)

- Introduced in 1953 (in US)
- Used in US, Canada, Japan…
- ~30fps interlaced (odd/even line fields), ~60Hz AC
- 480/525 lines used
- Aspect ratio = 4:3
- Optionally an MTS (Multichannel Television Sound) may be included for stereo…

PAL (Phase Alternating Line)

- Introduced in 1967 (by Walter Bruch in Germany)
- PAL-I (UK), PAL-B/G (much of Europe), PAL-M (Brasil),…
- 25fps interlaced (50Hz AC), 576/625 lines used
- Part of the colour information reversed in phase with each line (automatically corrects phase errors in the transmission of the signal).
- Optional NICAM stereo sound

SECAM (Sequentiel Couleur Avec Mémoire)

- Introduced in 1967 (in France)
- Used in France, Eastern Europe, Russia…
- R-Y and B-Y information is transmitted (sequentially) in alternate lines, and a video line store is used to combine the signals together => the vertical colour resolution is halved relative to PAL and NTSC

TV Standards Summary

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Connectors

- Coaxial or RF (All audio/picture components of all channels are modulated onto one wire)
- Composite (All audio/video components for one channel on one wire) (YUV)
- S-Video (two wires – one for brightness, one for colour) (Y/C video)
- Component video – 3 separate connectors (brightness + 2 colour [hue and saturation]) (Y, B-Y, R-Y) (Y-P_B-Y, P_R-Y)
- SCART (may carry Composite, S-Video or RGB video with two channel audio + control signals)
Colourspace representations

- **RGB (Red, Green, Blue)** – Basic analog components (from camera/to TV)
- **YPbPr (Y,B-Y,R-Y)** – ANALOG colourspace (derived from RGB) Y=Luminance, B=Blue, R=Red
- **YUV** – Colour difference signals scaled to be modulated on a composite carrier
- **YIQ** – Used in NTSC, I=In-phase, Q=Quadrature (IQ plane is 33° rotation of UV plane)
- **YCbCr/YCC** – DIGITAL representation of the YPbPr colourspace (8bit, 2s compliment)

RGB to YUV Conversion

\[
Y = 0.299R + 0.587G + 0.114B \\
U = (B-Y) \times 0.565 \\
V = (R-Y) \times 0.713 \\
\]
clamp the output: \(Y=[16, 235]\), \(U,V=[16,239]\)

Gamma Correction

- a power law relationship that approximates the relationship between the encoded luminance in a television system and the actual desired image brightness
- The light intensity \(L\) is related to the source voltage \(V_s\) by the following formula:
  \[
  L \propto (V_s)^\gamma 
  \]
where \(\gamma\) is the Greek letter gamma

Digitisation (sampling)

- **YUV 4:4:4** = 8bits per Y,U,V channel (no downsampling the chroma channels)
- **YUV 4:2:2** = 4 Y pixels sampled for every 2 U and 2 V (2:1 horizontal downsampling, no vertical downsampling)
- **YUV 4:2:0** = 2:1 horizontal downsampling, 2:1 vertical downsampling
- **YUV 4:1:1** = 4 Y pixels sampled for every 1 U and 1 V (4:1 horizontal downsampling, no vertical downsampling)

YUV 4:4:4 sample positions

Luma = X, Chroma = O
YUV 4:2:2 sample positions

YUV 4:2:0 sample positions

MPEG-1/H.261/H.263 Positions

MPEG-2 Positions

Video Format

- Resolution:
  - PAL full resolution: 833x625 (4:3 aspect ratio)
  - PAL visible resolution (Super CIF): 704x576
  - CIF (Common Image Format): 352x288
  - QCIF (Quarter CIF): 176x144
  - NTSC full resolution: 700x525 (4:3 aspect ratio)
  - NTSC visible resolution: 640x480
  - SIF (Standard Input Format): 352x240
  - QSIF (Quarter SIF): 176x120
- Colour: YV12 (12-bit packed format)
  - Y,UV = 8bit/pixel
  - 4 pixels (YYYYUV) 6 bytes = 12bits/pixel on average

Colour mapping

- Palette: no. of possible different colours
- Indexed colour
  - eg RGB: 24-bit/16.7 million colours, GIF: 8-bit/256 colours
  - Choose most common 256 colours (from the set of 16.7 million), map them to the 24-bit range and store the colour palette with the picture data.
  - other colours are approximated to one of the 256 colours (either ditheredclosest colour/ etc.)
- True colour
  - No colour mapping is required

Uncompressed video rate

- Examples (CCIR [ITU-R] 601)
  - PAL signal: 864x625 resolution, YUV4:2:2 20bit/pixel colour, 25fps = 270Mbps
  - PAL signal: 864x625 resolution, YUV4:2:2 16bit/pixel colour, 25fps = 216Mbps
  - PAL video: 720x576 resolution, YUV4:2:2 16bit/pixel colour, 25fps = 166Mbps (~20MB/s, ~1GB/min)
- DV (Firewire): 400Mbps, USB2.0: 480Mbps