

Video Introduction

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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

	fps	lines	Band-width (MHz)	Video b/w (MHz)	B&w mod.	Colour mod.	Audio Mod.
NTSC	30	525	6	4.2	AM	QAM	FM
PAL	25	625	7-8	5-6	AM	QAM	FM
SECAM	25	625	7-8	5-6	AM	FM	FM

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-P_r)
- 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

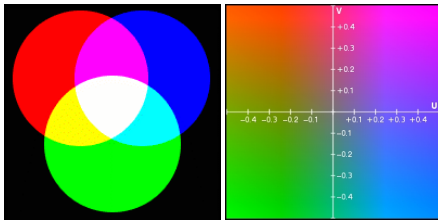
$$Y = 0.299R + 0.587G + 0.114B$$

$$U = (B-Y) * 0.565$$

$$V = (R-Y) * 0.713$$

clamp the output: Y=[16, 235], U,V=[16,239]

Examples of RGB and U-V colour planes



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:

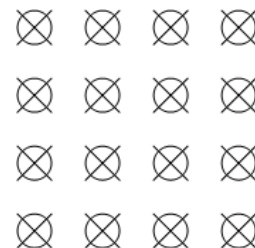
$$L \propto (V_s)^\gamma$$

where γ is the Greek letter gamma

Digitisation (sampling)

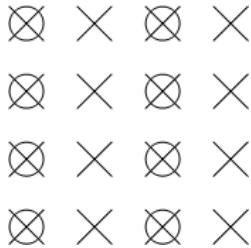
- YUV 4:4:4 = 8bits per Y,U,V channel (no downsampling the chroma channels)
- YUV 4:2:2 = 4 Y pixels sampled for every 2 U and 2 V (2:1 horizontal downsampling, no vertical downsampling)
- YUV 4:2:0 = 2:1 horizontal downsampling, 2:1 vertical downsampling
- YUV 4:1:1 = 4 Y pixels sampled for every 1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

YUV 4:4:4 sample positions

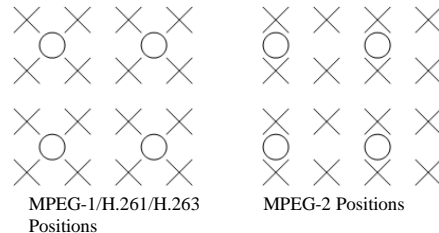


Luma = X, Chroma = O

YUV 4:2:2 sample positions



YUV 4:2:0 sample positions



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,U,V = 8bits/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 dithered/closest colour/etc.)
 - Can use 4-bit (16 colour) range as well
- 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