3.4. Basics of Video

Types of Color Video Signals
Analog Video
Digital Video

- *Reference:* Chapter 5 of Steinmetz and Nahrstedt

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

3.4.1 Types of Color 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.

3.4.2 Analog Video

The following figures are from A.M. Tekalp, "Digital video processing", Prentice Hall PTR, 1995.

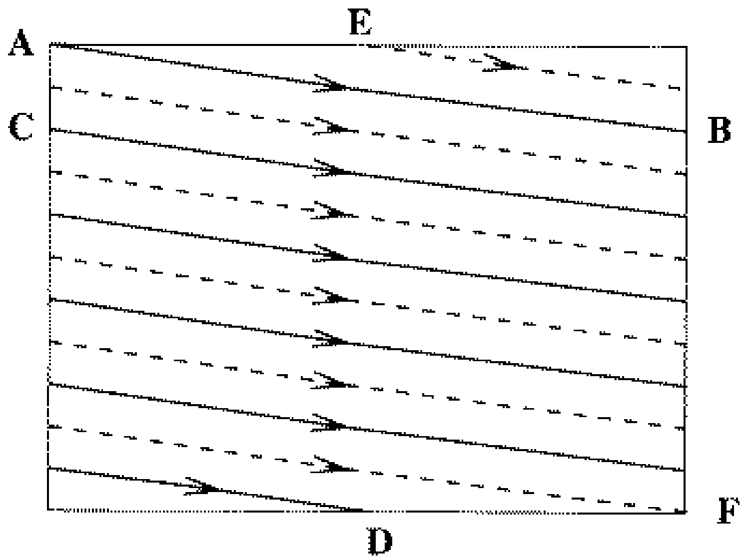


Figure 1.1: Scanning raster.

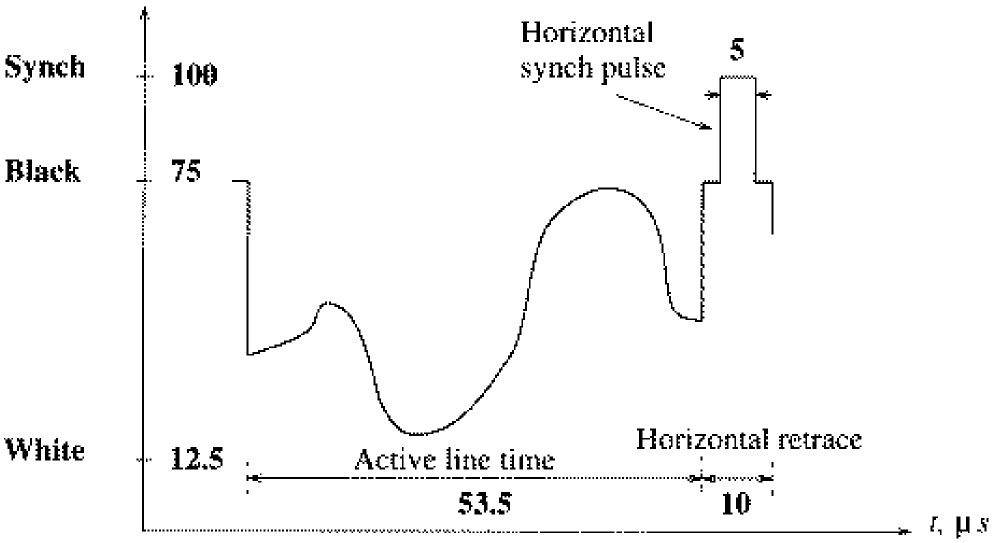
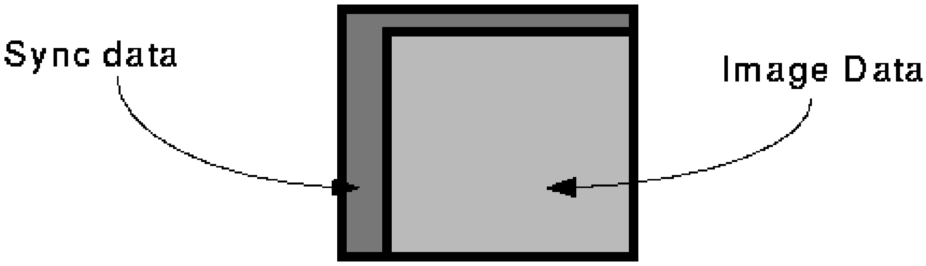


Figure 1.2: Video signal for one full line.

NTSC Video

- 525 scan lines per frame, 30 frames per second (or be exact, 29.97 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. Horizontal retrace takes 10 microseconds (with 5 microseconds horizontal synch pulse embedded), so the active line time is 53.5 microseconds.



Digital Video Rasters

- Color representation:
  - NTSC uses YIQ color model.
  - composite = Y + I *cos*(Fsc t) + Q *sin*(Fsc t), where Fsc is the frequency of color subcarrier

PAL Video

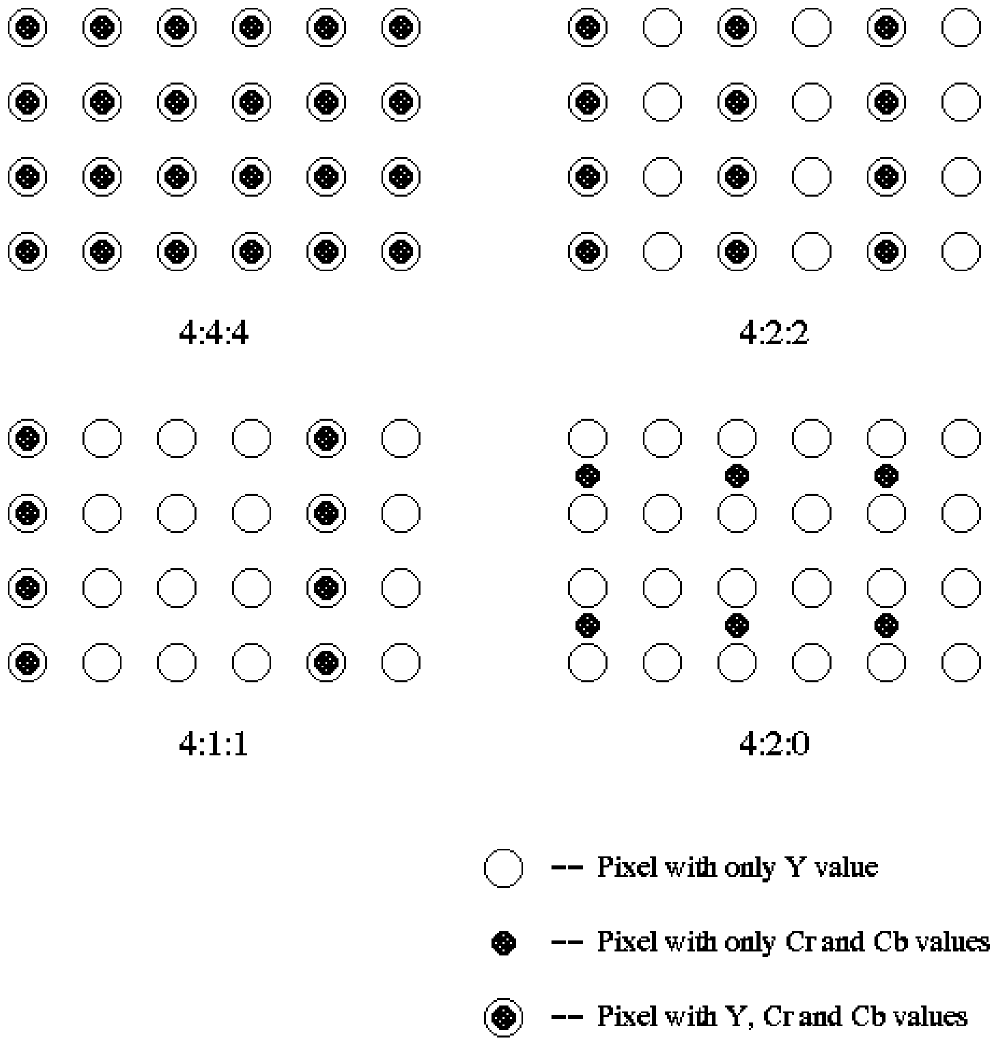
- 625 scan lines per frame, 25 frames per second (40 msec/frame)
- Interlaced, each frame is divided into 2 fields, 312.5 lines/field
- Uses YUV color model

3.4.3 Digital Video

- **Advantages:**
  - 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

Chroma Subsampling

- How to decimate for chrominance?



- 4:4:4 --> No chroma subsampling, each pixel has Y, Cr and Cb values.

  4:2:2 --> Horizontally subsample Cr, Cb signals by a factor of 2.

  4:1:1 --> Horizontally subsampled by a factor of 4.

  4:2:0 --> Subsampled in both the horizontal and vertical dimensions by a factor of 2. Theoretically, the chroma pixel is positioned between the rows and columns as shown in the figure.

- 4:1:1 and 4:2:0 are mostly used in JPEG and MPEG (see Chapter 4).

CCIR Standards for Digital Video

(CCIR -- Consultative Committee for International Radio)

	CCIR 601 525/60 NTSC	CCIR 601 625/50 PAL/SECAM	CIF	QCIF
Luminance resolution	720 x 485	720 x 576	352 x 288	176 x 144
Chrominance resolut.	360 x 485	360 x 576	176 x 144	88 x 72
Color Subsampling	4:2:2	4:2:2	4:2:0	4:2:0
Fields/sec	60	50	30	30
Interlacing	Yes	Yes	No	No

- CCIR 601 uses interlaced scan, so each field only has half as much vertical resolution (e.g., 243 lines in NTSC). The CCIR 601 (NTSC) data rate is ~165 Mbps.

- CIF (Common Intermediate Format) -- an acceptable temporary standard
  - Approximately the VHS quality
  - Uses progressive (non-interlaced) scan
  - Uses NTSC frame rate, and half the active lines of PAL signals --> To play on existing TVs, PAL systems need to do frame rate conversion, and NTSC systems need to do line-number conversion.

- QCIF -- Quarter-CIF

ATSC Digital Television Standard

(ATSC -- Advanced Television Systems Committee) The **ATSC Digital Television Standard** was recommended to be adopted as the Advanced TV broadcasting standard by the FCC Advisory Committee on Advanced Television Service on November 28, 1995. It covers the standard for **HDTV** (High Definition TV).

Video Format

The video scanning formats supported by the ATSC Digital Television Standard are shown in the following table.

Vertical Lines	Horizontal Pixels	Aspect Ratio	Picture Rate
1080	1920	16:9	60I 30P 24P
720	1280	16:9	60P 30P 24P
480	704	16:9 & 4:3	60I 60P 30P 24P
480	640	4:3	60I 60P 30P 24P

- The aspect ratio for HDTV is 16:9 as opposed to 4:3 in NTSC, PAL, and SECAM. (A 33%

increase in horizontal dimension.)

- In the picture rate column, the "I" means interlaced scan, and the "P" means progressive (non-interlaced) scan.
- Both NTSC rates and integer rates are supported (i.e., 60.00, 59.94, 30.00, 29.97, 24.00, and 23.98).
- At 1920 x 1080, 60I (which CBS and NBC have selected), there will be 1920 x 1080 x 30 = 62.2 millions pixels per second. Considering 4:2:2 chroma subsampling, each pixel needs 16 bits to represent, the bit rate is 62.2 x 16 = 995 Mb/sec.

Further Exploration

Homepage of the Advanced Television Systems Committee (ATSC)

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