Chapter Five

Fundamental Concepts in Video

Since video is created from a variety of sources, we begin with the signals themselves. Analog video is represented as a continuous (time-varying) signal, and the first part of this chapter discusses how it is measured. Digital video is represented as a sequence of digital images, and the second part of the chapter discusses standards and definitions such as HDTV.

5.1 Types of Video signal

Video signals can be organized in three different ways: *Component video, Composite video,* and *S-video*

Component Video

Higher-end video systems, such as for studios, make use of three separate video signals for the red, green, and blue image planes. This is referred to as *component video.* This kind of system has three wires (and connectors) connecting the camera or other devices to a TV or monitor.

Color signals are not restricted to always being RGB separations. Instead, as we saw in ·Chapter4 on color models for images and video, we can form three signals via a luminance chrominance transformation of the RGB signals - for example, YIQ or YUV. In contrast, most computer systems use component video, with separate signals for R, G, and B signals. For any color separation scheme, component video gives the best color reproduction, since there is no "crosstalk" between the three different channels, unlike composite video or S-video. Component video, however, requires more bandwidth and good synchronization of the three components.

Composite Video

In *composite video,* color ("chrominance") and intensity ("luminance") signals are mixed into a *single* carrier wave. Chrominance is a composite of two color components *(I* and Q, or *U* and *V).* This is the type of signal 'used by broadcast color TVs; it is downward compatible with black-and-white TV.

In NTSC TV, for example [1], [and *Q* are combined into a chroma signal, and a color sub-carrier then puts the chroma signal at the higher frequency end of the channel shared with the luminance signal. The chrominance and luminance components can be separated at the receiver end, and the two color components can be further recovered.

S-**Video**

As a compromise, *S-video* (separated video, or super-video, e.g" in S-VHS) uses two wires: one for luminance and another for a composite chrominance signal. As a result, there is less crosstalk between the color information and the crucial gray-scale information.

The reason for placing luminance into its own part of the signal is that black-and-white information is crucial for visual perception. As noted in the previous chapter, humans are able to differentiate spatial resolution in grayscale images much better than for the color part of color images (as opposed to the "black-and-white" part). Therefore, color information sent can be much less accurate than intensity information. We can see only fairly large blobs of color, so it makes sense to send less color detail

5.2 Analog Video

Most TV is still sent and received as an analog signal. Once the electrical signal is received, we may assume that brightness is at least a monotonic function of voltage, if not necessarily linear, because of gamma correction

An analog signal f*(t)* samples a time-varying image. So-called *progressive* scanning traces through a complete picture (a frame) row-wise for each time interval. A high resolution computer monitor typically uses a time interval of *1/72* second.

In TV and in some monitors and multimedia standards, another system, *interlaced* scanning, is used. Here, the odd-numbered lines are traced first, then the even-numbered lines. This results in "odd" and "even" *fields* - two fields make up one frame. In fact, the odd lines (starting from 1) end up at the middle of a line at the end of the odd field, and the even scan starts at a half-way point.

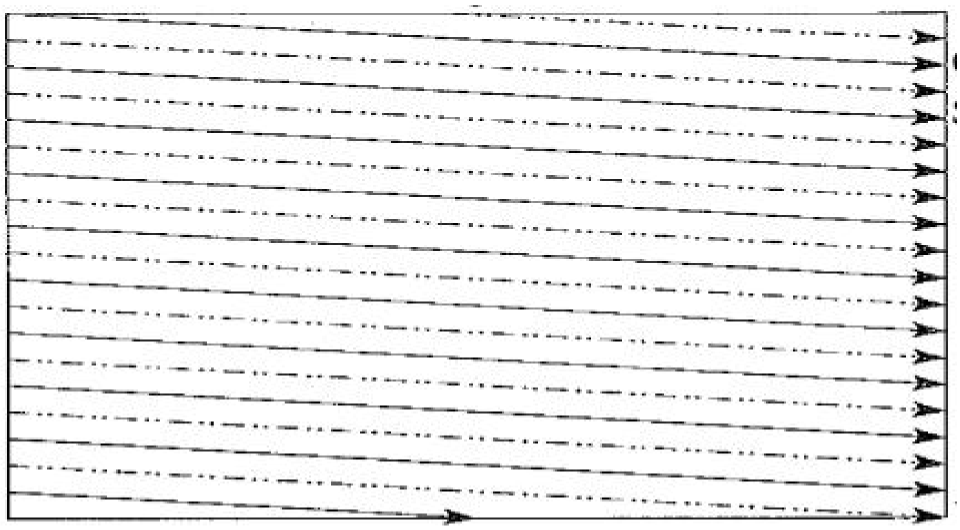

Figure Interlaced raster scan

Interlacing was invented because, when standards were being defined, it was difficult to transmit the amount of information in a full frame quickly enough to avoid flicker. The double number of fields presented to the eye reduces perceived flicker.

Because of interlacing, the odd and even lines are displaced in time from each other. This is generally not noticeable except when fast action is taking place onscreen, when blurring may occur

NTSC Video

The NTSC TV standard is mostly used in North America and Japan. It uses a familiar 4:3 *aspect ratio* (i.e., the ratio of picture width to height) and 525 scan lines per frame at 30 frames per second

More exactly, for historical reasons NTSC uses 29.97 fps -or, in other words, 33.37 msec per frame

NTSC follows the interlaced scanning system, and each frame is divided into two fields, with 262.5 lines/field.

PAL Video

PAL (Phase Alternating Line) is a TV standard originally invented by German scientists. It uses 625 scan lines per frame, at 25 frames per second (or 40 msec!frame), with a 4:3 aspect ratio and interlaced fields. Its broadcast TV signals are also used in composite video. This important standard is widely used in Western Europe, China, India and many other parts of the world.

PAL uses the YUV color model with an 8 MHz channel, allocating a bandwidth of 5.5 MHz to Y and 1.8 MHz each to U and V. The color subcarrier frequency is *fsc* ~4.43 MHz.

SECAM Video

SECAM, which was invented by the French, is the third major broadcast TV standard. SECAM stands for *Systeme Electronique Couleur avec Momoire.* SECAM also uses 625 scan lines per frame, at 25 frames per second, with a 4:3 aspect ratio and interlaced fields.

The Oliginal design called for a higher number of scan lines (over 800), but the final version settled for 625.

SECAM and PAL are similar, differing slightly in their color coding scheme. In *SECAM,*

U and V signals are modulated using separate color subcarriers at 4.25 MHz and 4.41 MHz,

respectively. They al'e sent in alternate lines - that is, only one of the U or V signals will be sent on each scan line.

5.3 Digital Video

The advantages of digital representation for video are many. It permits

- Storing video on digital devices or in memory, ready to be processed (noise removal, cut and paste, and so on) and integrated into various multimedia applications
- Direct access, which makes nonlinear video editing simple
- Repeated recording without degradation of image quality
- Ease of encryption and better tolerance to channel noise

In earlier Sony or Panasonic recorders, digital video was in the form of composite video.

Modem digital video generally uses component video, although RGB signals are first converted into a certain type of color opponent space, such as YUV. The usual color space is YCbCr [5].

TV system	Frame rate (fps)	Number of scan lines	Total channel width (MHz)	Bandwidth allocation (MHz)		
				Y	*I* or *U*	*Q* or *V*
NTSC	29.97	525	6.0	4.2	1.6	0.6
PAL	25	625	8.0	5.5	1.8	1.8
SECAM	25	625	8.0	6.0	2.0	2.0

TABLE .: Comparison of analog broadcast TV systems.

5.4 Different TV standard

The introduction of wide-screen movies brought the discovery that viewers seated near the screen enjoyed a level of participation (sensation of immersion) not experienced with conventional movies. Apparently the exposure to a greater field of view, especially the involvement of peripheral vision, contributes to the sense of "being there". The main thrust of High Definition TV (HDTV) is not to increase the "definition" in each unit area, but rather to increase the visual field, especially its width.

First-generation HDTV was based on an analog technology developed by Sony and NHK in Japan in the late 1970s. HDTV successfully broadcast the 1984 Los Angeles Olympic Games in Japan. MUltiple sub-Nyquist Sampling Encoding (MUSE) was an improved NHK HDTV with hyblid analog/digital technologies that was put in use in the 1990s. It has 1,125 scan lines, interlaced (60 fields per second), and a 16:9 aspect ratio. It uses satellite to broadcast ~ quite appropriate for Japan, which can be covered with one or two satellites.

The Direct Broadcast Satellite (DBS) channels used have a bandwidth of 24 :MHz.

In general, terrestrial broadcast, satellite broadcast, cable, and broadband networks are all feasible means for transmitting HDTV as well as conventional TV.

The FCC has planned to replace all analog broadcast services with digital TV broadcasting by the year 2006. Consumers with analog TV sets will still be able to receive signals via an 8-VSB (8-level vestigial sideband) demodulation box. The services provided will include

- Standard Definition TV (SDTV) ~ the current NTSC TV or higher
- Enhanced Definition TV (EDTV) - 480 active lines or higher
- High Definition TV (HDTV) - 720 active lines or higher. So far, the popular choices are 720*P*(720 lines, progressive, 30 fps) and 1080l (1,080 lines, interlaced, 30 fps or 60 fields per second). The latter provides slightly better picture quality but requires much higher bandwidth.