Fundamentals of Multimedia

Fundamental Concepts in Video

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Outlines

the principal notions needed to understand video

- Analog video
- Digital video
- Video display interfaces
- 3D video

Video

Since video is created from a variety of sources, we begin with the signals themselves

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

Analog Video

- **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 s.

- 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.

interlacing

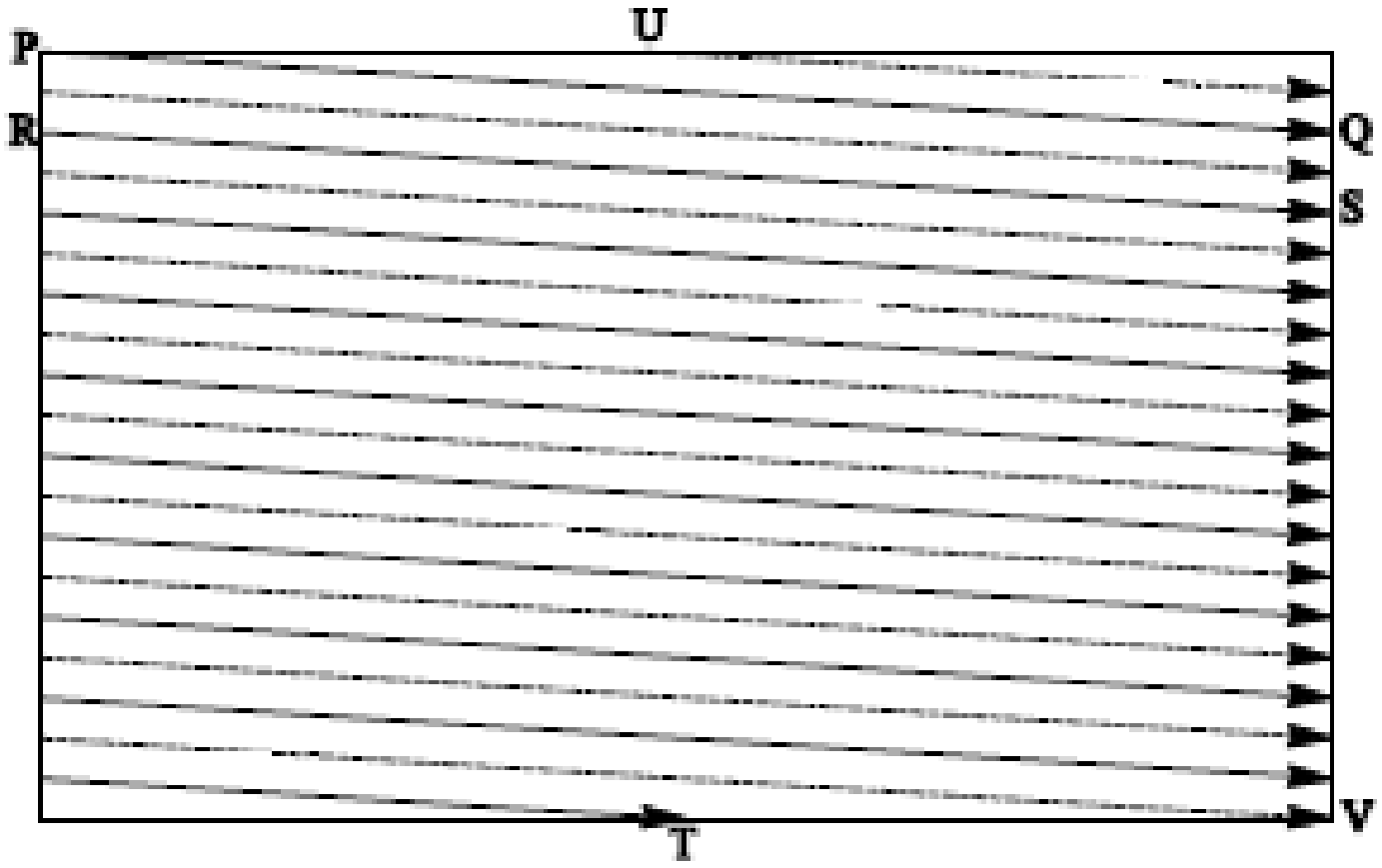


Fig. 5.1: Interlaced raster scan

interlacing

- 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 5.1 (previous slide) shows the scheme used.
- First the solid (odd) lines are traced—P to Q, then R to S, and so on, ending at T
- Then the even field starts at U and ends at V.
- The scan lines are not horizontal because a small voltage is applied, moving the electron beam down over time.

interlacing

- 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 the eye perceived flicker.
- The jump from Q to R and so on in Fig. 5.1 is called the horizontal retrace, during which the electronic beam in the CRT is blanked.
- The jump from T to U or V to P is called the vertical retrace.

NTSC Video

- NTSC stands for (National Television System Committee of the U.S.A)
- 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 (interlaced) scan lines per frame at 30 fps.

1 NTSC Video

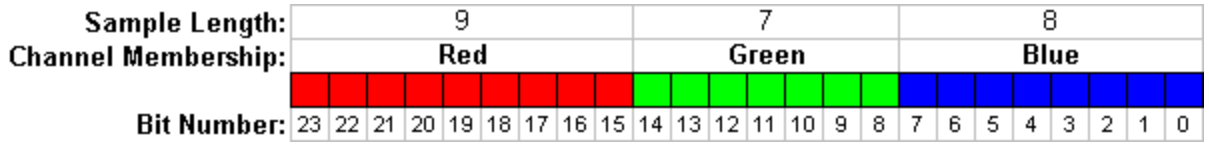
- Blanking information is placed into 20 lines reserved for control information at the beginning of each field.
- Hence, the number of *active video lines* per frame is only 485.
- Similarly, almost 1/6 of the raster at the left side is blanked for horizontal retrace and sync.
- The nonblanking pixels are called *active pixels*.
- Image data is not encoded in the blanking regions, but other information can be placed there, such as V-chip information, stereo audio channel data, and subtitles in many languages.

NTSC Video

- NTSC video is an analog signal with no fixed horizontal resolution.
- Therefore, we must decide how many times to sample the signal for display.
- Each sample corresponds to one pixel output.
- A pixel clock divides each horizontal line of video into samples.
- The higher the frequency of the pixel clock, the more samples per line.

Sampling

- a sample is an intersection of channel and a pixel
- The diagram below depicts a 24-bit pixel, consisting of 3 samples for Red (channel) , Green (channel) , and Blue (channel) .
- In this particular diagram, the Red sample occupies 9 bits, the Green sample occupies 7 bits and the Blue sample occupies 8 bits, totaling 24 bits per pixel



- A sample is related to a subpixel on a physical display.

Vertical Trace

- Alternatively referred to as a **vertical blanking interval** or the **vertical sync signal**, **vertical retrace** is used to describe the action performed within the computer monitor that turns the monitor beam off when moving it from the lower-right corner of a monitor to the upper-left of the monitor.

- This action takes place each time the beam has completed tracing the entire screen to create an image.

2 PAL Video

- PAL (Phase Alternating Line) is a TV standard originally invented by German scientists.

- This important standard is widely used in Western Europe, China, India, and many other parts of the world.
- Because it has higher resolution than NTSC, the visual quality of its pictures is generally better.

3 SECAM Video

- SECAM, which was invented by the French, is the third major broadcast TV standard.
- SECAM stands for Système Electronique Couleur Avec Mémoire.

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

Table 5.2: Comparison of Analog Broadcast TV Systems

TV System	Frame Rate fps	#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

Digital Video

- The advantages of digital representation for video:
  - ✓ 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.

CCIR and ITU-R Standards for Digital Video

- CIF is a compromise حل وسط between NTSC and PAL, in that it adopts the NTSC frame rate and half the number of active lines in PAL.

- When played on existing TV sets, NTSC TV will first need to convert the number of lines, whereas PAL TV will require frame rate conversion.
- The idea of CIF, which is about the same as VHS quality, is to specify a format for lower bitrate.
- CIF uses a progressive (noninterlaced) scan.
- QCIF stands for Quarter-CIF, and is for even lower bitrate.

High-Definition TV

- The introduction of wide-screen movies brought the discovery that viewers seated near the screen enjoyed a level of participation (sensation of immersion انغمار) not experienced with conventional movies.
- Apparently the exposure to a greater field of view, especially the involvement of peripheral محيطيvision, 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.

High-Definition TV

- MUltiple sub-Nyquist Sampling Encoding (MUSE) was an improved NHK HDTV with hybrid 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. (compare with NTSC 4:3 aspect ratio)
- In 1987, the FCC decided that HDTV standards must be compatible with the existing NTSC standard and must be confined to the existing Very High Frequency (VHF) and Ultra High Frequency (UHF) bands.

Ultra High Definition TV (UHDTV)

- UHDTV is a new development—a new generation of HDTV!
- The standards announced in 2012
- The aspect ratio is 16:9.
- The supported frame rate has been gradually increased to 120 fps.

Video Display Interfaces

- We now discuss the interfaces for video signal transmission from some output devices (e.g., set-top box, video player, video card, and etc.) to a video display (e.g., TV, monitor, projector, etc.).

- There have been a wide range of video display interfaces, supporting video signals of different formats (analog or digital, interlaced or progressive), different frame rates, and different resolutions

- We start our discussion with
  - analog interfaces, including **Component Video**, **Composite Video**, and **S-Video**,
  - and then digital interfaces, including **DVI**, **HDMI**, and **DisplayPort**.

Analog Display Interfaces

- Analog video signals are often transmitted in one of three different interfaces:
  - Component video,
  - Composite video, and
  - S-video.
- Figure 5.7 shows the typical connectors for them

Fig. 5.7 Connectors for typical analog display interfaces. From left to right: **Component video**, **Composite video**, **S-video**, and **VGA**

Analog Display Interfaces

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.

Analog Display Interfaces

Composite Video

- When connecting to TVs or VCRs, composite video uses only one wire (and hence one connector, such as a BNC connector at each end of a coaxial cable or an RCA plug at each end of an ordinary wire), and video color signals are mixed, not sent separately.

- The audio signal is another addition to this one signal.

Analog Display Interfaces

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

Analog Display Interfaces

Video Graphics Array (VGA)

- The Video Graphics Array (VGA) is a video display interface that was first introduced by IBM in 1987, along with its PS/2 personal computers. It has since been widely used in the computer industry with many variations, which are collectively referred to as VGA.

- The initial VGA resolution was 640×480 pixels.

- The VGA video signals are based on analog component RGBHV (red, green, blue, horizontal sync, vertical sync).

Digital Display Interfaces

- Given the rise of digital video processing and the monitors that directly accept digital video signals, there is a great demand toward video display interfaces that transmit digital video signals.
- Such interfaces emerged in 1980s (e.g., Color Graphics Adapter (CGA)
- Today, the most widely used digital video interfaces include Digital Visual Interface (DVI), High-Definition Multimedia Interface (HDMI), and Display Port, as shown in Fig. 5.8.

Fig. 5.8 Connectors of different digital display interfaces. From left to right: **DVI**, **HDMI**, **DisplayPort**

Digital Display Interfaces

Digital Visual Interface (DVI)

- Digital Visual Interface (DVI) was developed by the *Digital Display Working Group* (DDWG) for transferring digital video signals, particularly from a computer's video card to a monitor.
- It carries uncompressed digital video and can be configured to support multiple modes, including DVI-D (digital only), DVI-A (analog only), or DVI-I (digital and analog).
- The support for analog connections makes DVI backward compatible with VGA (though an adapter is needed between the two interfaces).
- The DVI allows a maximum 16:9 screen resolution of 1920×1080 pixels.

Digital Display Interfaces

High-Definition Multimedia Interface (HDMI)

- HDMI is a newer digital audio/video interface developed to be backward-compatible with DVI.

2, 560×1, 600

- HDMI, however, differs from DVI in the following aspects:

1. HDMI *does not carry analog* signal and hence is not compatible with
2. DVI is limited to the RGB color range (0–255).
3. HDMI supports digital audio, in addition to digital video.

- The HDMI allows a maximum screen resolution of 2560×1600 pixels.

Digital Display Interfaces

Display Port

- Display Port is a digital display interface. It is the first display interface that uses **packetized data transmission**, like the Internet or Ethernet
- Display Port can achieve a higher resolution with fewer pins than the previous technologies.
- The use of data packets also allows Display Port to be extensible, i.e., new features can be added over time without significant changes to the physical interface itself.
- Display Port can be used to transmit audio and video simultaneously, or either of them.
- Compared with HDMI, Display Port has slightly more bandwidth, which also accommodates multiple streams of audio and video to separate devices.

3D Video and TV

- the rapid progress in the research and development of 3D technology and the success of the 2009 film Avatar have pushed 3D video to its peak.
- The main advantage of the 3D video is that it enables the experience of immersion be there, and really Be there!
- Increasingly, it is in movie theaters, broadcast TV (e.g., sporting events), personal computers, and various handheld devices.