CMPT 365 Multimedia Systems

Media Representations - Video

Spring 2024

Outline

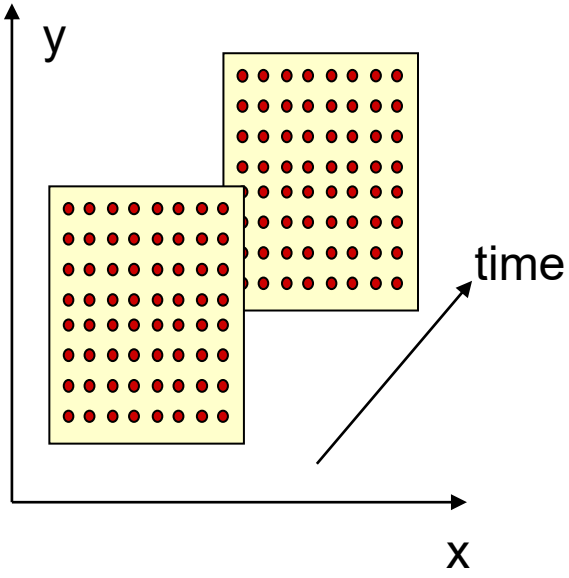
- Analog Video
- Digital Video
- Video Interfaces
- HDTV
- Further Exploration

Analog Video

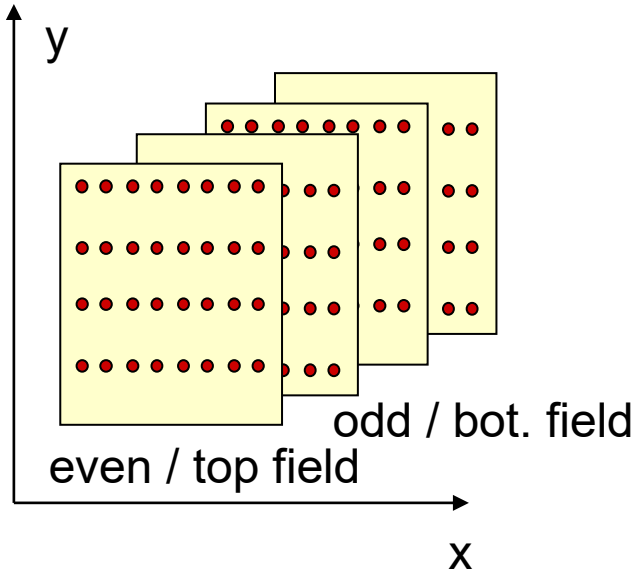
- An analog signal $f(t)$ samples a time-varying image
- Progressive scanning
  - traces through a complete picture (a frame) row-wise for each time interval.
- Interlaced scanning
  - Odd-numbered lines traced first, and then the even-numbered lines.
  - "odd" and "even" fields - two fields make up one frame
  - Widely used in traditional (non-digital) TV

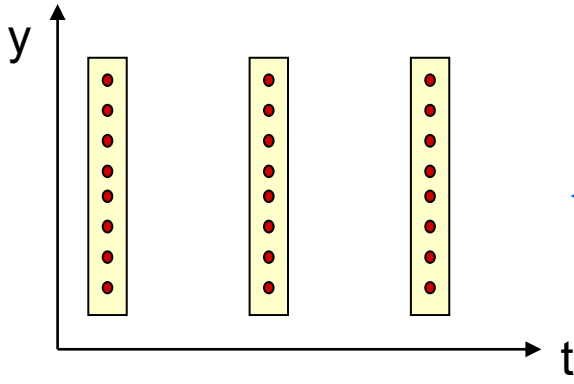
Digital vs Analog TV Signal

Digital video:
Progressive Frame
All lines

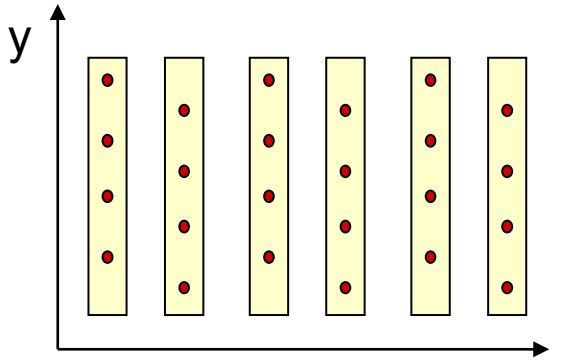


TV signal:
Interlaced Fields: even lines or odd lines only
Tradeoff between frame rate and bandwidth

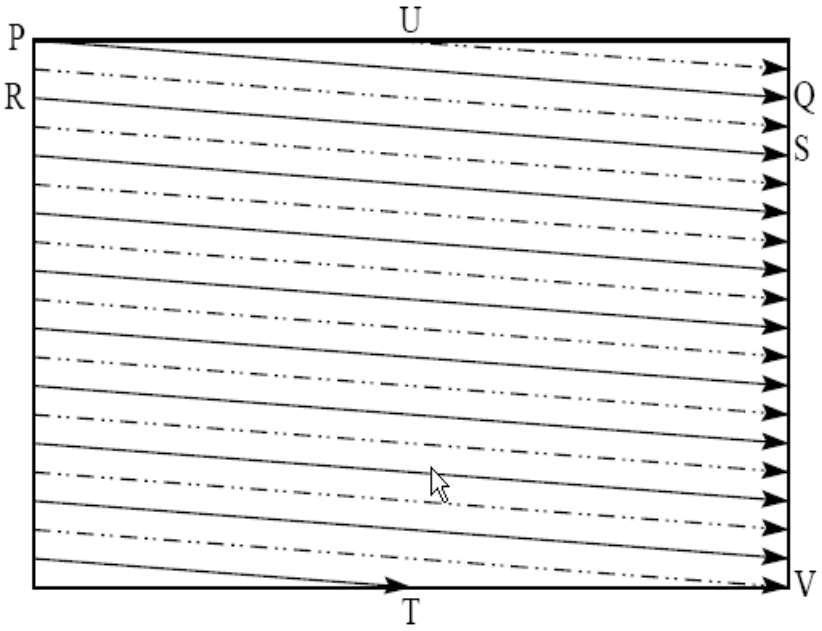




De-interlacing



Interlaced Scan

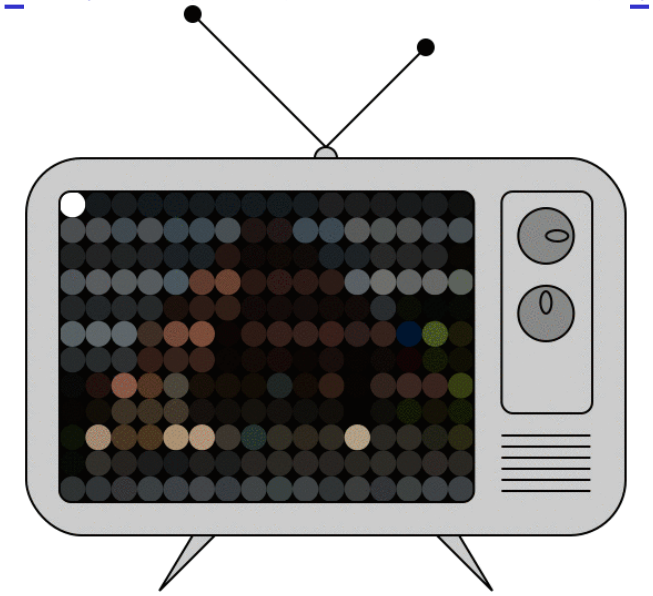


- First the solid (odd) lines are traced, P to Q, then R to S, etc., ending at T; then the even field starts at U and ends at V.

- The jump from Q to R, etc. 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**

Interlaced Scan



https://en.wikipedia.org/wiki/Interlaced_video

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Example of Interlaced Scan

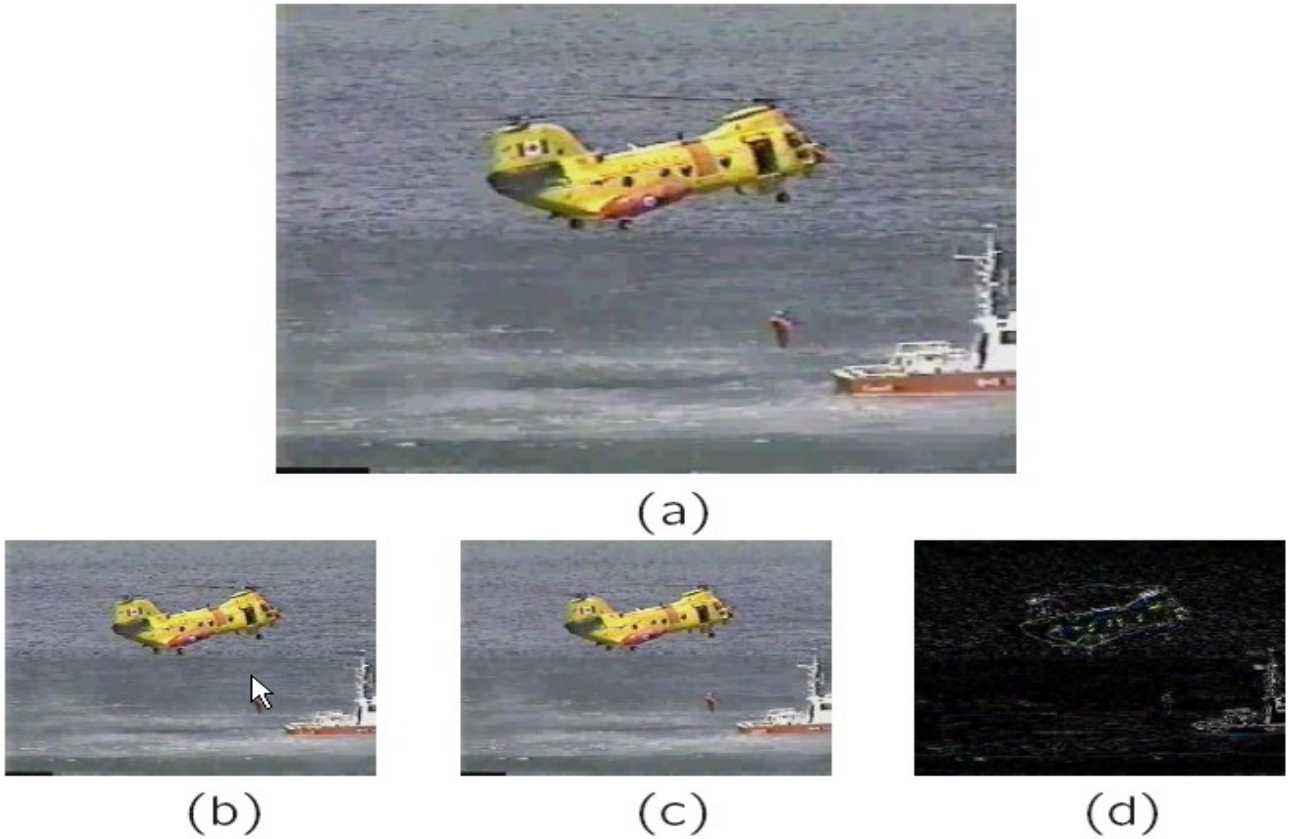

Fig. 5.2: Interlaced scan produces two fields for each frame. (a) The video frame, (b) Field 1, (c) Field 2, (d) Difference of Fields

NTSC Video

- **NTSC** (National Television System Committee) TV standard is mostly used in North America and Japan
  - YIQ color model
  - 4:3 **aspect ratio** (i.e., the ratio of picture width to its height)
  - 525 scan lines per frame at 30 frames per second (fps).
- Interlaced scanning, and each frame is divided into two fields, with 262.5 lines/field
  - horizontal sweep frequency is 525x29.97 = 15,734 lines/sec,
  - each line is swept out in 1/15,734 = 63.6 us
  - the horizontal retrace takes 10.9 us, this leaves 52.7 us for the active line signal during which image data is displayed
- PAL in Asia/Europe, SECAM in Europe
- All faded out (Canada, Aug 31, 2011)

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Digital Video

- Why digital video ?
- Advantages
  - Stored on digital device or in memory
  - Faithful duplication in digital domain
    - Good or bad ?
  - Direct (random) access,
    - nonlinear video editing achievable as a simple, rather than a complex task
  - Ease of manipulation (noise removal, cut and paste, etc.)
  - Ease of encryption and better tolerance to channel noise
    - Multimedia communications
  - Integration to various multimedia applications

ITU-R digital video specifications

	CCIR 601 525/60 NTSC	CCIR 601 625/50 PAL/SECAM	CIF	QCIF
Luminance resolution	720 x 480	720 x 576	352 x 288	176 x 144
Chrominance resolution	360 x 480	360 x 576	176 x 144	88 x 72
Colour Subsampling	4:2:2	4:2:2	4:2:0	4:2:0
Fields/sec	60	50	30	30
Interlaced	Yes	Yes	No	No

Note, CIF is a compromise of NTSC and PAL in that it adopts the 'NTSC frame rate and half of the number of active lines as in PAL.

CCIR-601

- CCIR-601 for component digital video
  - specified by Consultative Committee for International Radio (CCIR)
  - aspect ratio of 4:3
  - interlaced scan, so each field has only half as much vertical resolution
  - Now become standard ITU-R-601, adopted by many digital video formats including the popular DV video.

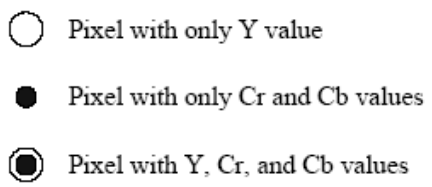
CIF

- CIF: Common Intermediate Format
  - Specified by CCITT (***C**omité **C**onsultatif **I**nternational **T**éléphonique et **T**élégraphique*).
- A format for lower bitrate
  - CIF is about the same as VHS quality.
  - Progressive (non-interlaced) scan.
- QCIF: "Quarter-CIF"
- CIF/QCIF resolutions are evenly divisible by 8, and all except 88 are divisible by 16; this provides convenience for block-based video coding in H.261 and H.263, discussed later

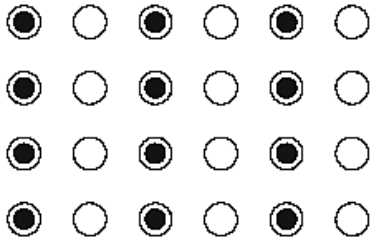
Chroma Subsampling

- Since humans see color with much less spatial resolution than they see black and white, it makes sense to subsample chrominance signal
- Interesting (but not necessarily informative!) names have arisen to label the different schemes used.
  - 4:4:4
  - 4:2:2
  - 4:1:1
  - 4:2:0
- To begin with, numbers are given stating how many pixel values, per four original pixels, are actually sent:
  - The chroma subsampling scheme 4:4:4 indicates that no chroma subsampling is used: each pixel's Y, Cb and Cr values are transmitted, 4 for each of Y, Cb, Cr.

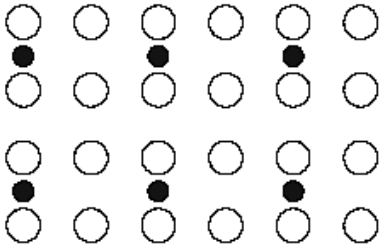
Chroma Subsampling cont'd



- 4:2:2: *horizontal subsampling* of the Cb, Cr signals by a factor of 2.
  - of four pixels horizontally labelled as 0 to 3, all four Ys are sent, and every two Cb's and two Cr's are sent, as (Cb0, Y0)(Cr0, Y1)(Cb2, Y2)(Cr2, Y3)(Cb4, Y4), and so on (or averaging is used).



- 4:2:0: subsamples in *both the horizontal and vertical* dimensions by a factor of 2.
  - an average chroma pixel is positioned between the rows and columns.



- Scheme 4:2:0 along with other schemes is commonly used in JPEG and MPEG (more later).

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Analog Video Display Interfaces

Component video, Composite video, S-video, VGA

Component video

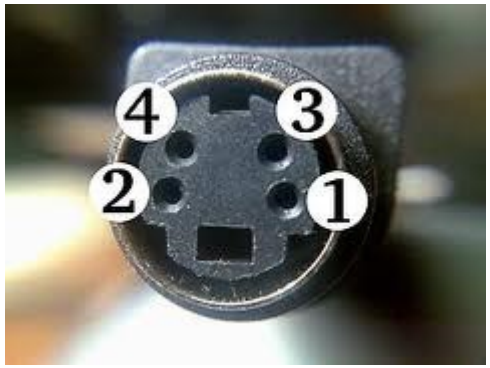
- **Component video**: three separate video signals for the red, green, and blue image planes. Each color channel is sent as a separate video signal.
  - For higher-end video systems
  - Supported by most computer systems
  - Best color reproduction
    - no "crosstalk" between the three channels.
  - But more bandwidth and good synchronization

Composite Video - 1 Signal

- **Composite video**: color ("chrominance") and brightness ("luminance") signals are mixed into a *single* wire
  - **Chrominance** (I and Q, or U and V).
    - Combined into a chroma signal, and then put at the high-frequency end of the signal shared with the luminance signal Y.
  - Chrominance and luminance components separated at the receiver end and then two color components be further recovered.
  - Only one wire for video signal
    - Audio signals added through separate wires
- Interference is inevitable.

S-Video - 2 Signals

- **S-Video**: Separated video, or Super-video
  - a compromise, with two wires
  - one for luminance and another for a composite chrominance signal.
  - Less crosstalk between color and the crucial gray-scale information.
- Reason for placing luminance into its own part
  - black-and-white is most crucial for visual perception.
    - Both in terms of brightness and spatial resolution
    - Less information for color is fine



VGA (Video Graphics Array)

- Analog only
- Introduced with IBM x86 machines (1987), but became a universal analog display interface
- R, G, B, plus power, syn, control etc
- A VGA (D-sub) connector

Digital Display Interfaces

Digital interfaces emerged in 1980s (e.g., Color Graphics Adapter (CGA), and evolved rapidly.

- Connectors of different digital display interfaces: DVI, HDMI, DisplayPort.

DVI (Digital Visual Interface)

- Uncompressed digital video
- Almost a ubiquitous computer display link replacing VGA (since 1999)
- Uncompressed video only
  - R, G, B (both digital and analog)
  - plus clock, syn, power, control etc.

- Single link: 1920x1080 60Hz
- Dual link: 2560x1600 60Hz

HDMI (High-Definition Multimedia Interface)

- (2002) backward-compatible with DVI
- RGB or YCbCr + digital audio
  - + bidirectional audio, ethernet
- High bandwidth digital content protection (HDCP)
- HDMI 1.3 2560x1600

Display Port

- (2006) Packetized transmission (like Internet)
  - 4K video support
- Royalty-free (HDMI is not!)

- Variation/enhancement: Thunderbolt

Example: DVD Player

Example: Home Theatre Receiver

Example: Xbox 360

- Simple package vs premium package

Example: PS4

TECHINSIGHTS

teardown.com

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HDTV

- Main objective of **HDTV** (High Definition TV)
  - not necessary to increase the "definition" in each unit area
  - but rather to increase the visual field especially in its width.
- First generation of HDTV
  - an analog technology developed by Sony and NHK in Japan in the late 1970s.
- MUSE (MUltiple sub-Nyquist Sampling Encoding)
  - an improved NHK HDTV with hybrid analog/digital technologies in the 1990s.
  - 1,125 scan lines, interlaced (60 fields per second), and 16:9 aspect ratio.
- Need for compressions
  - uncompressed HDTV will easily demand more than 20 MHz bandwidth, which will not work in the current 6 MHz or 8 MHz channels
  - high quality HDTV signals would be transmitted using more than one channel even after compression.

More about HDTV

- For video, MPEG-2 is chosen as the compression standard.
- For audio, *AC-3* is the standard
  - supports 5.1 channel Dolby surround sound -- 5 surround channels plus a subwoofer channel
- Difference between conventional TV and HDTV:
  - Much wider aspect ratio of 16:9 instead of 4:3.
  - All progressive (non-interlaced) scan
    - interlacing introduces serrated edges to moving objects and flickers along horizontal edges
    - Upsampling ? 120 Hz, 200 Hz ?

HDTV in North America

- 1987: FCC (Federal Communications Commission) decided that HDTV standards must be compatible with existing NTSC and be confined to the existing VHF (Very High Frequency) and UHF (Ultra High Frequency) bands.
- 1990: FCC announced a very different initiative
  - preference for a full-resolution HDTV
  - HDTV would be simultaneously broadcast with the existing NTSC TV and eventually replace it.
- 1993: after a boom of proposals for digital HDTV, the FCC made a key decision to go all-digital.
  - A "grand alliance" was formed that included four main proposals, by General Instruments, MIT, Zenith, and AT&T, and by Thomson, Philips, Sarnoff and others.
  - This eventually led to the formation of the ATSC (Advanced Television Systems Committee) -- responsible for the standard for TV broadcasting of HDTV.
- 1995: U.S. FCC Advisory Committee on Advanced Television Service recommended that the ATSC Digital Television Standard be adopted.

Advanced Digital Formats by ATSC

# of Active Pixels per line	# of Active Lines	Aspect Ratio	Picture Rate
1,920	1,080	16:9	60P 60I 30P 24P
1,280	720	16:9	60P 30P 24P
704	480	16:9 or 4:3	60P 60I 30P 24P
640	480	4:3	60P 60I 30P 24P

"I": interlaced scan
"P": progressive (non-interlaced) scan

Recent Advances

- The FCC (Federal Communications Commission) has planned to replace all analog broadcast services with digital TV broadcasting by the year 2006.
  - later delayed to June 12,2009 in US
  - Canada: August 31, 2011 (one year extension for some CBC transmitters)
- The services provided will include:
  - **SDTV (Standard Definition TV)**: the current NTSC TV or higher
  - **EDTV (Enhanced Definition TV)**: 480 active lines or higher, i.e., the third and fourth rows in the Table
  - **HDTV (High Definition TV)**: 720 active lines or higher

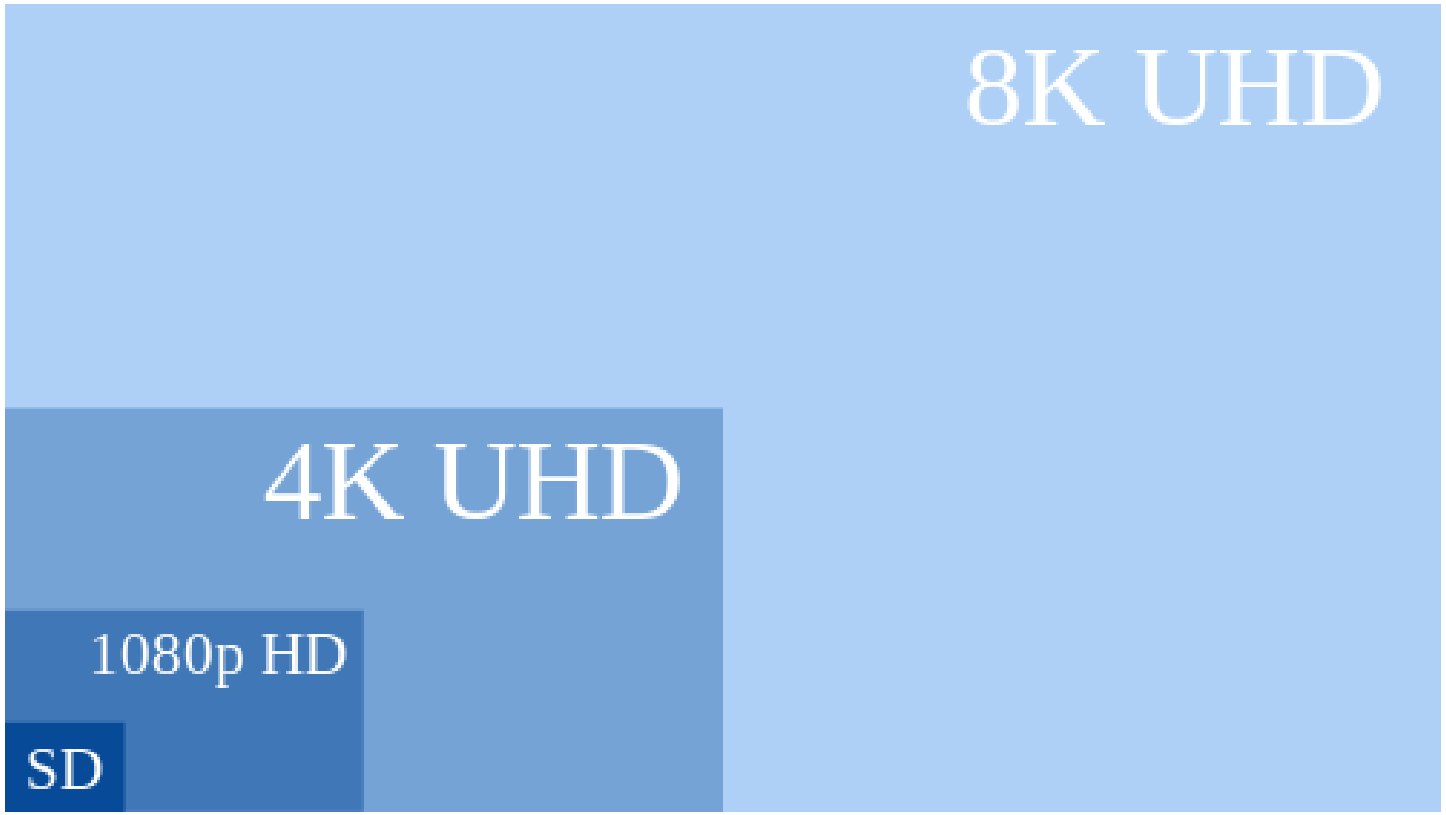
Ultra High Definition TV (UHD, or 4K)

- Announced in 2012
  - 4K UHDTV: 2160P (3,840×2,160, progressive scan) and 8K UHDTV: 4320P (7,680×4,320, progressive scan).
- Aspect ratio is 16:9. Bit-depth can be up to 12 bits, and the chroma subsampling can be 4:2:0 or 4:2:2.
- Supported frame rate has been gradually increased to 120 fps.

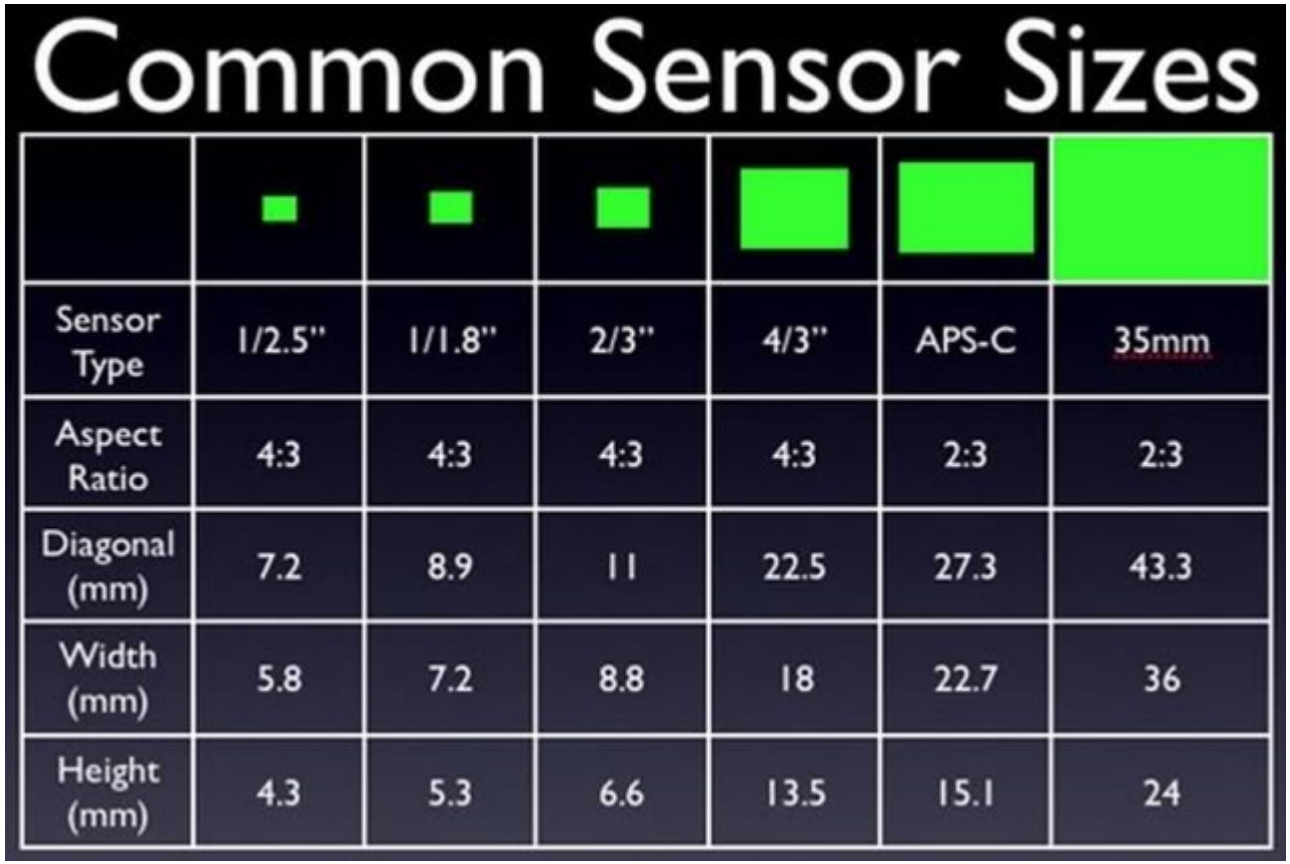
UHDTV will provide superior picture quality, comparable to IMAX movies, but it will require a much higher bandwidth and bitrate – 40MBps encoded !

VR/AR? 16K video ?

Ultra High Definition TV (UHD, or 4K)



CCD/CMOS Image Sensor Size



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- Types of Video Signals
- Analog Video
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Further Exploration

- Chapter 5.1, 5.2, 5.3