Université Pierre-Mendès France

Digital multimedia

# Video Representation

# Outline

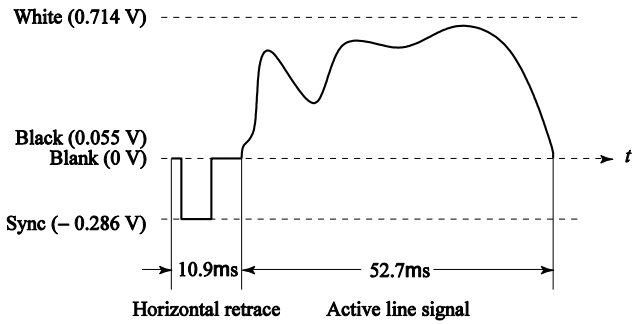
1. **Representation of media**
   - Text
   - Image
   - ~~Audio~~
   - **Video**
     - Video Types and Signal Transmission
     - Broadcast Standards
     - File Types

# Video

- Captures **motion** as a **sequence of pictures** at a constant-time interval
  - Each picture is called a **frame**
- **Frame rate** specifies how fast the pictures are captured or played back
  - Measured in **frames per second** (**fps**)

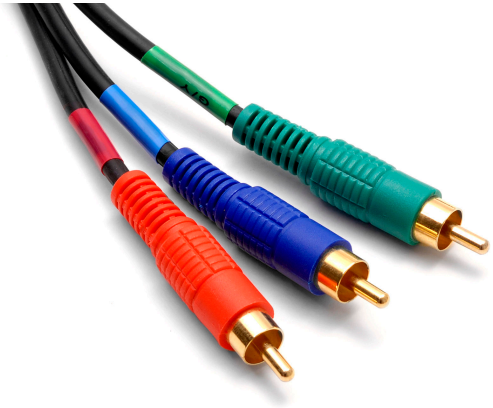
# Video Types

- **Analog Video**
  - Continuous **time-varying** signal




- **Digital Video** ( DV )
  - **Ordered** set of digital images

# Video Signal Transmission



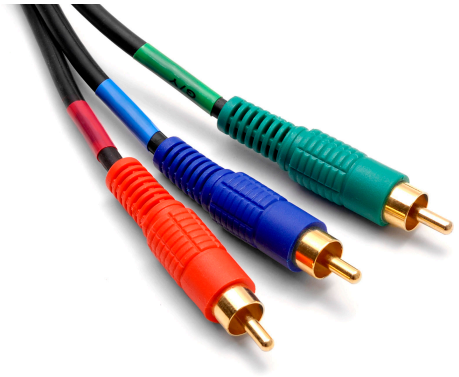
**Component Video**

**Composite Video**

**S-Video**

# Component Video

- Uses 3 separate **video signals** for the red, green, and blue image colors
- Used in several computers
- Gives the best **color reproduction** since there is **no** “**crosstalk**” between the three signal



# Composite Video

- **Color** and **intensity** signals are **mixed** into a **single signal**
  - Color (“**chrominance**”) is a composition of two color components
    → I and Q, or U and V in the YUV and YIQ color models
  - Intensity (“luminance”) only involves greyscale
    → Backward compatible with Black and White Television

- Since **color** and **intensity** are **wrapped** into the **same signal** some interference between them is inevitable

# Composite Video

- Relationships between **RGB** and **YUV/YIQ**

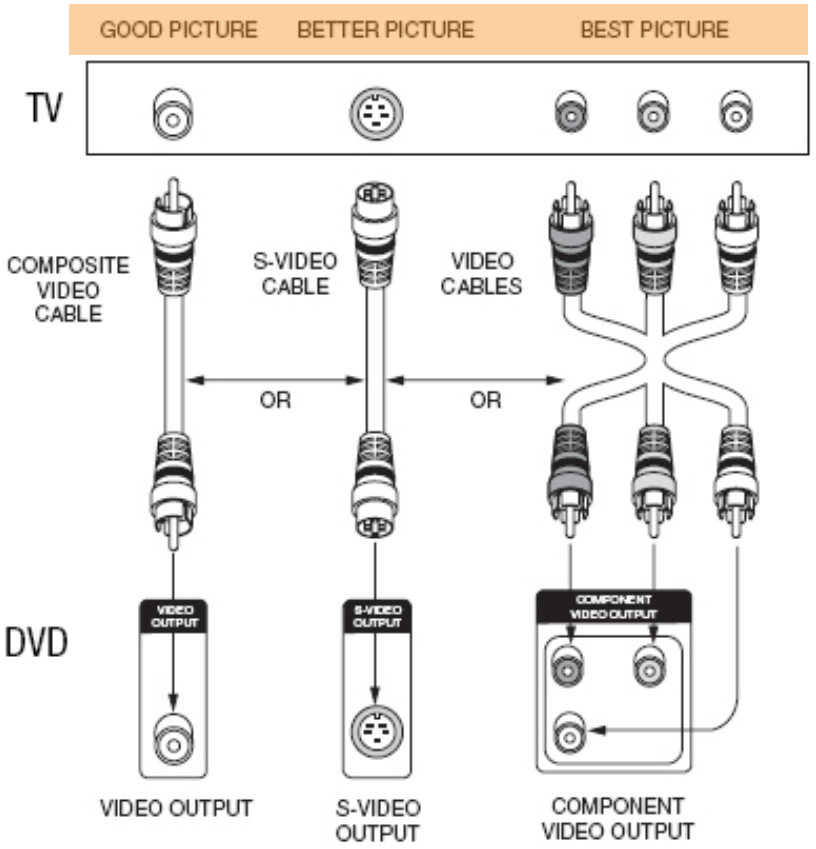
$$
\begin{aligned}
Y &= 0.299R + 0.587G + 0.114B \\
U &= 0.492(B - Y) = -0.147R - 0.289G + 0.436B \\
V &= 0.877(R - Y) = 0.615R - 0.515G - 0.100B
\end{aligned}
$$

$$
\begin{aligned}
Y &= 0.299R + 0.587G + 0.114B \\
I &= 0.596R - 0.275G - 0.321B \\
Q &= 0.212R - 0.523G + 0.311B
\end{aligned}
$$

# S-Video

- Uses **two wires**
  - one for luminance
  - another for chrominance
- **Less crosstalk** between the **color** information and the crucial **gray-scale** information

# Video Signal Quality



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     - Video Types and Signal Transmission
     - **Broadcast Standards**
     - File Types

# TV Broadcast Standards

- Define
  - How pictures are **encoded** and **transmitted** as broadcast signals
  - The **frame rate** and the **scan lines** in each frame
- **Influenced digital video** standards
  - Ex. "*the number of lines in each frame in the analog broadcast standard is translated to the pixel height of a frame in digital video*"

# Standards

- **NTSC**
  - designated by the U.S.'s National Television Systems Committee
  - U.S., Japan, Taiwan, North, large part of America
- **PAL**
  - Phase Alternating Line
  - Australia, New Zealand, Western Europe, Asian
- **SECAM**
  - Séquentiel Couleur avec Mémoire
  - France, former Soviet Union, Eastern Europe

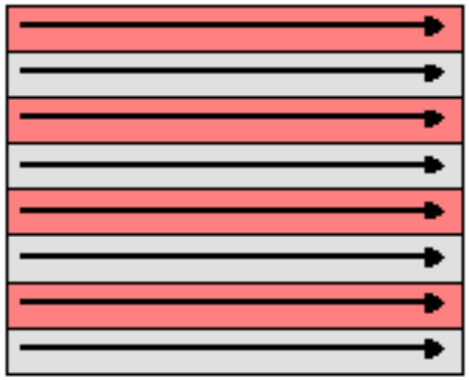
*** Note: Africa and Asia are mostly influenced by their colonial histories

# Standards Frame Rates

| Video Type | Frame Rate (fps) |
|---|---|
| NTSC (black-and-white) | 30 |
| NTSC (color) | 29.97 |
| PAL | 25 |
| SECAM | 25 |
| Motion-picture film | 24 |

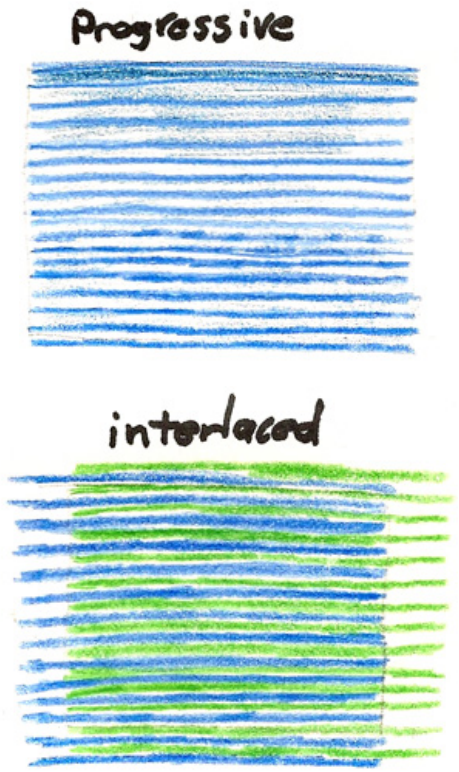
# How Monitors and TVs Display Pictures

- Pictures displayed on monitors and TVs are made up of **horizontal lines**
  - NTSC: **525 lines** (about 480 lines are picture)
  - PAL and SECAM: **625 lines** (about 576 lines are picture)
- Lines are traced across the screen
  - one line at a time
  - from top to bottom

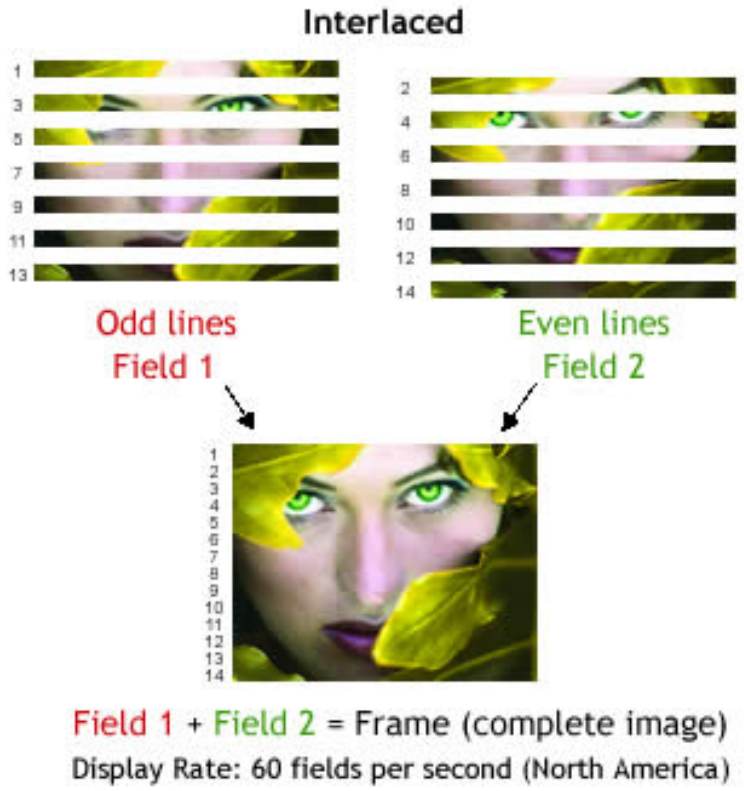


# Ways of Tracing Lines From Top to Bottom

- **Progressive scan**
  - Lines are traced from top to bottom in one pass
- **Interlaced scan**
  - Lines are traced in two passes:
    1. Even-numbered lines (**upper field**)
    2. Odd-numbered lines (**lower field**)

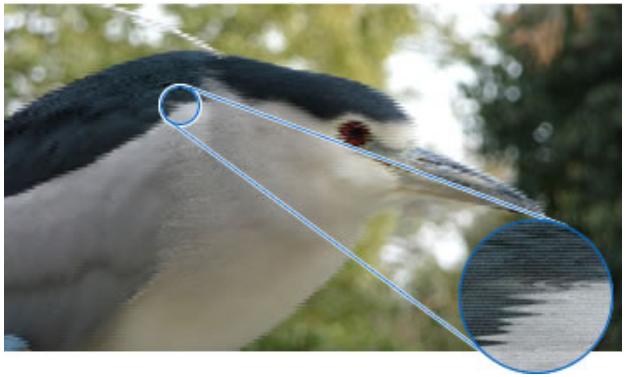


# Ways of Tracing Lines From Top to Bottom

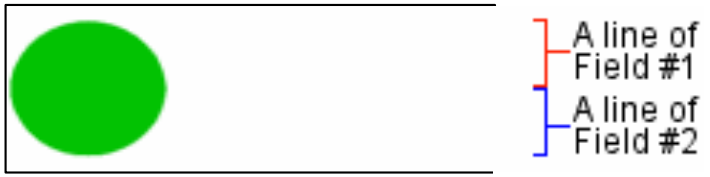



# Interlace Artifacts

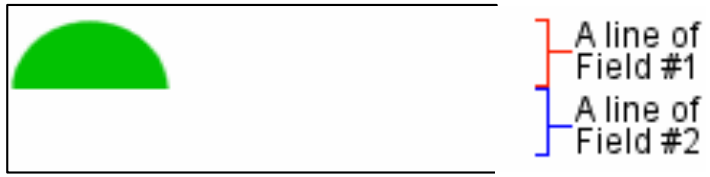
- **Split of an image** across fields **due to motion**
  - Produced because the 2 fields in a frame are captured at a slightly different moment in time
- Not discernible during normal playback of most videos



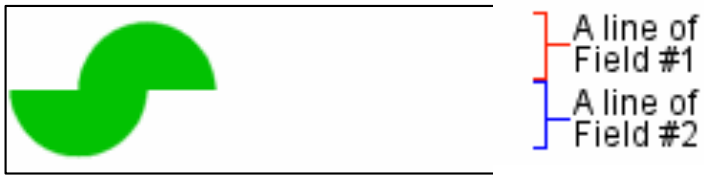
# Interlace Artifacts



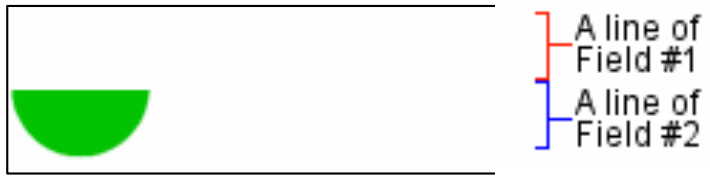

Progressive video on progressive display




Progressive video on Interlaced display




Interlaced video on an interlaced display




Interlaced video on a Progressive display

# De-Interlace

- **Method** for **removing** the interlace artifact
  1. Discard one field (upper or lower field)
  2. Fill in the gaps by duplicating or interpolating the other field

**Without upper field**

**Without lower field**

- **Disadvantage**
  - "**Ghosting**" effect caused by the blending of the two unique fields within a single frame of video.

# Frame Rate and Frame Size

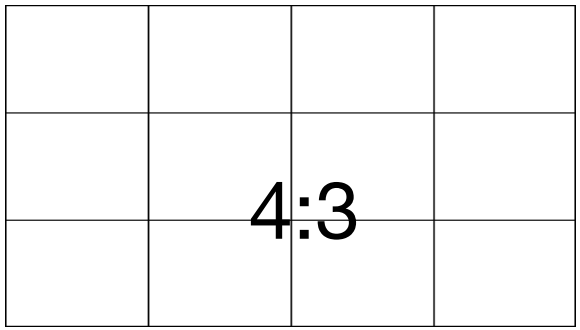
- **Frame rate**
  - Specifies **how frequent** you take a snapshot of the motion
  - Higher the frame rate :
    - More accurate the motion is sampled
    - More frames for the same duration ➔ increments the size of the file !!
- **Frame size** ( i.e. resolution )
  - Frames are images → they have a resolution measured in pixels
  - Unlike digital images, there is **no pixel per inch** (ppi) setting for video because video is not intended for print

# Frame Size Examples

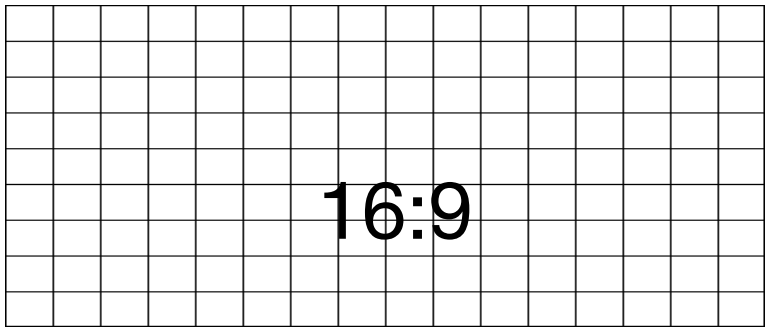
| Standard | | Frame size |
|---|---|---|
| NTSC | Standard definition | 720 x 480 pixels |
| | High definition<br>(HDV format) | 1280 x 720 pixels<br>1440 x 1080 pixels |
| PAL | Standard definition | 720 x 576 pixels |

# Frame Aspect Ratio

- Ratio of a frame's **viewing** *width* to *height*
  - NOT equivalent to ratio of the frame's *pixel* width to height.



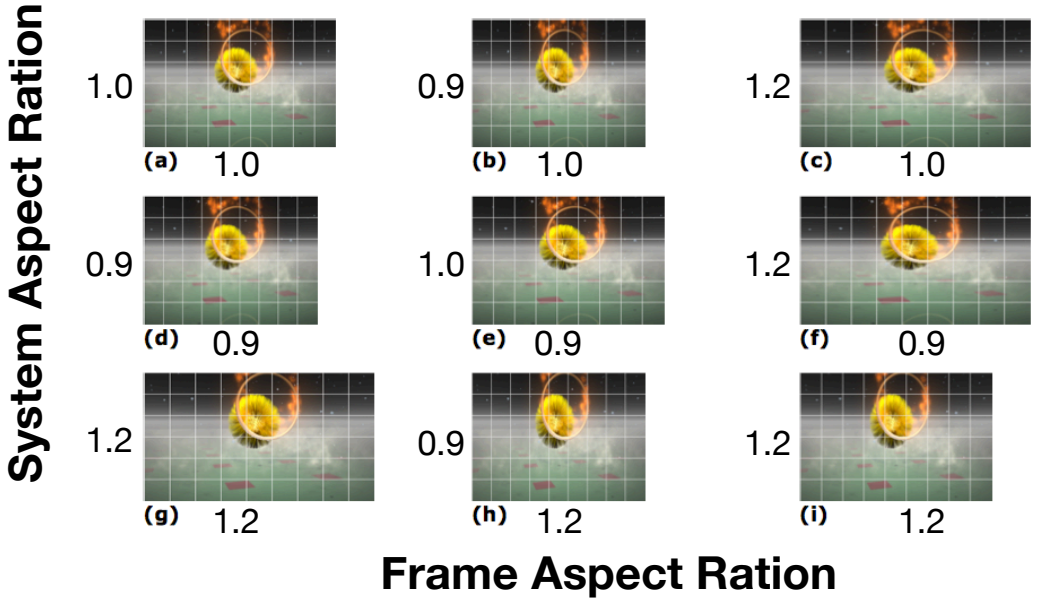

Example:
• Standard definition NTSC standard format



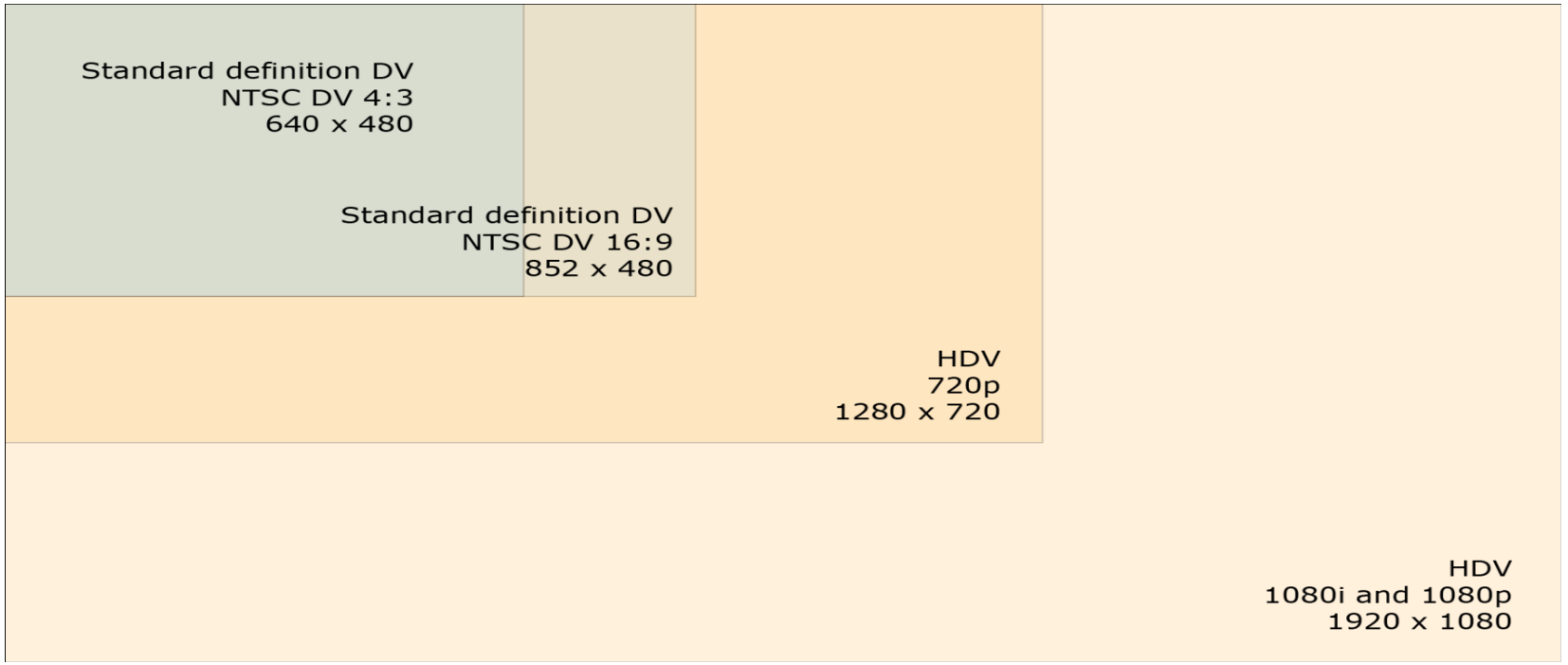

Examples:
• Standard definition NTSC wide-screen format
• High definition digital video
• High definition TV

# Distortion of Aspect Ratio

| Pixel Apect Ratios | Distortion | Example |
|---|---|---|
| video frame's = display system's | none | (a), (d), (g), (i) |
| video frame's < display system's | stretched horizontally | (c), (e), (f) |
| video frame's > display system's | stretched vertically | (b), (h) |

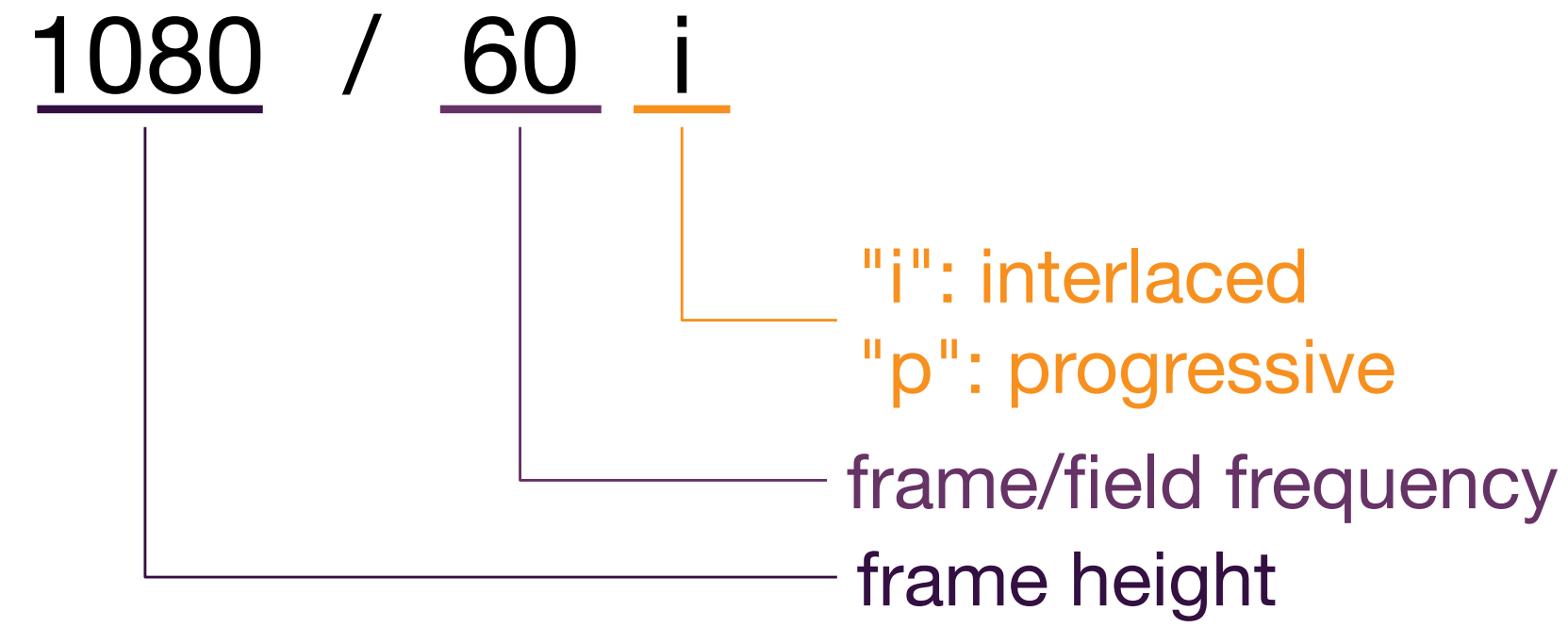


# Frame Size (Resolution) Comparison between Standard Definition and High Definition




By viewing frame size

# Picture Format Notation



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# Common Video File Types

| File Type | Acronym For | Originally Created By | File Info & Compression | Platforms |
|---|---|---|---|---|
| **.mov** | QuickTime movie | Apple | • Also audio-only<br>• Can be streamed<br>• "Fast start"<br>• Common compression methods: H.264, Sorenson Video, Animation | Apple QuickTime player, which is available for Mac and Windows |
| **.avi** | Audio Video Interleave | Intel | Common compression methods: Microsoft RLE, Intel Indeo Video | Primarily used on Windows but Apple QuickTime player can play AVI files |
| **.mpg**<br>**.mpeg** | MPEG | Motion Picture Experts Group | • For DVD-video<br>• High definition HDV | Cross-platform |
| **.divx** | | DivX, Inc | • Uses DivX codec, which is based on MPEG-4<br>• Popular format for movies because of the high<br>• image quality and small file size<br>• AVI is a common container file format | • May require downloading DivX codec<br>• Windows Media Player v11.0 comes with DivX codec |

# Common Video File Types

| File Type | Acronym For | Originally Created By | File Info & Compression | Platforms |
|---|---|---|---|---|
| **.mp4** | MPEG-4 | Moving Pictures Experts Group | • Video codec: H.264<br>• Audio codec: AAC<br>• One of the HTML5 video formats | Plays in Web browsers that support the MP4 format of HTML5 video **(Safari and IE)** |
| **.ogg or .ogv** | Audio Video Interleave | Xiph.Org Foundation | • Video codec: Theora<br>• Audio codec: Vorbis<br>• One of the HTML5 video formats<br>• Compared to the other two HTML5 video formats, it has lower quality for the same file size | Plays in Web browsers that support the OGG format of HTML5 video (**Firefox, Chrome, Opera**) |
| **.webm** | | An open source video format from Google | • Video codec: VP8<br>• Audio codec: Vorbis<br>• One of the HTML5 video formats | Plays in Web browsers that support the WebM format of HTML5 video (**Firefox, Chrome, Opera**) |

# Common Video File Types

| File Type | Acronym For | Originally Created By | File Info & Compression | Platforms |
|---|---|---|---|---|
| **.flv** | Flash Video | Adobe | • **Progressive download**<br>• **Can be streamed**<br>• Common compression methods: H.264, Sorenson Spark, On2 VP6 | • **Cross-platform**<br>• Requires Adobe Media Player to play |

# Considerations for File Type

- Size restriction
  - For the Web, CD or DVD ?
- Intended audience
  - Specific platform or multiplatform
  - Streaming, pseudo-streaming or download
- Future editing
  - No → Use compression
  - Yes → Do not compress (only if you have enough disk space)

# Video File Size

- Video tends to have very large file size compared to other media
- Why should we care file size optimization?
  - A large file requires more disk space
  - A large file takes longer to transfer
  - Data transfer can be expensive (because data plans are not unlimited)
  - High *data rate* may cause choppy playback of the video.

# Video File Size

- To get a feel of the file size of uncompressed video:

  What is the size of a **1-minute** video with **24-bit color** and **720-by-480** pixel frame size at a frame rate of **29.97 fps**?

| | |
|---|---|
| **Total pixels in each frame** | 720 x 480 = 345,600 pixels/frame |
| **File size for each frame** (bits) | 345,600 pixels/frame x 24 bits/pixel = 8,294,400 bits/frame |
| **Size in bits for 1 minute** | 8,294,400 bits/frame x 29.97 frames/second x 60 seconds = 14 914 990 080 bits |
| **Size in bytes** | 14 914 990 080 bits / (8 bits/byte) = 1 864 373 760 bytes = 1.8 Gb (approx.) |

# Video Data Rate

- Amount of video to be processed by the computer

$$\text{Data Rate} = \frac{\text{File Size}}{\text{Duration of Video (seconds)}}$$

- In the previous example
  - Date Rate = 1 864 Mbytes / 60 sec = 31 MB/sec
  - Too high for a **72x** CD-ROM drive (approx. 11 MB/sec)

    → Very choppy playback
  - Good for a 34x DVD-ROM drive (approx. 33 MB/sec)

# Video File Size vs. Data Rate

- **Data rate**
  - If high: choppy playback
  - Amount of data to be processed per second

    → Larger file size can have a low data rate if it is a long video

    → Smaller file size can have a high data rate if it is a short video

- **File size**
  - If high:
    - Requires larger storage space
    - Not unnecessary choppy playback
  - The impact of file size on smoothness of playback also depends on the video duration

# Strategies for Reducing Video File Size

- General Strategies:
  - Reduce **frame size → less pixels** for each frame
  - Reduce **frame rate → less frames**
  - Choose a video **compressor** that allows **higher compression**
  - Choose the **lower picture quality** option
- **Reduce duration** of the video so you have **less frames**
  - Will not impact data rate

# Video (De)Compression

- **Codec**: compressor/de-compressor
- Compression:
  - Reduce file size
  - Takes time (more time for higher compression)
- Decompression:
  - A compression video file must be decompressed before it is played
  - The decompression method or algorithm depends on how it is originally compressed
- Compression and decompression always go together as a pair.

# MPEG (Moving Pictures Experts Group)

- Family of encoding formats for **high compression**
  - MPEG-1, MPEG-2, MPEG-4
- What happened to MPEG-3?
  - NOT MP3 (which is audio format)
  - Intended for HDTV
  - HDTV specifications was merged into MPEG-2

# MPEG (Moving Pictures Experts Group)

- MPEG-1
  - Originally **intended for the Web** and CD-ROM playback
  - Frame sizes up to 352 × 240 pixels
- MPEG-2
  - Supports DVD-video, HDTV, HDV standards
  - Compression based on **motion compensation**
- MPEG-4
  - Compression based on **motion prediction**
  - Identifies media objects in a scene

# Motion Compensation

- Algorithmic technique employed in MPEG-2 for **video compression**
- Exploits the fact that much of the **information** present in one frame will be present in next frames
  - Ex. A moving car in a scene