

An Elementary Introduction to Media Codecs

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A real-world example of media codecs

The screenshot shows the YouTube Help Center interface. The top navigation bar includes links for 'Help Center' (highlighted in blue), 'Community', 'Creator Tips', 'YouTube' with a search icon, and sections for 'Fix a problem', 'Watch videos', 'Manage your account & settings', 'Supervised experience on YouTube', 'YouTube Premium', 'Create & grow your channel' (highlighted in blue), 'Monetize with the YouTube Partner Program', and 'Policy, safety, & copyright'. Below this, a breadcrumb trail shows 'Upload videos > YouTube recommended upload encoding settings'. The main content area has a title 'YouTube recommended upload encoding settings' and a note: 'These features are only available to partners who use YouTube Studio Content Manager. Contact your YouTube Partner Manager to get access.' It lists recommended settings for 'Container: MP4', 'Audio codec: AAC-LC', and 'Video codec: H.264'. To the right, a sidebar titled 'Upload videos' lists various options: 'Set default upload settings', 'Skip sending upload notifications', 'Schedule video publish time', 'Add tags to your YouTube videos', 'Video resolution & aspect ratios', 'YouTube recommended upload encoding settings' (highlighted in blue), 'Supported YouTube file formats', and 'Find playlists & videos using hashtags'.

YouTube recommended upload encoding settings

⚠️ These features are only available to partners who use YouTube Studio Content Manager. Contact your [YouTube Partner Manager](#) to get access.

Below are recommended upload encoding settings for your videos on YouTube.

Container: MP4

- No Edit Lists (or the video might not get processed correctly)
- moov atom at the front of the file (Fast Start)

Audio codec: AAC-LC

- Channels: Stereo or Stereo + 5.1
- Sample rate 96khz or 48khz

Video codec: H.264

- Progressive scan (no interlacing)
- High Profile

Upload videos

- [Set default upload settings](#)
- [Skip sending upload notifications](#)
- [Schedule video publish time](#)
- [Add tags to your YouTube videos](#)
- [Video resolution & aspect ratios](#)
- [YouTube recommended upload encoding settings](#)
- [Supported YouTube file formats](#)
- [Find playlists & videos using hashtags](#)

YouTube recommended upload encoding settings



- Container
- Audio codec
- Video codec
- Frame rate
- Bitrate
- Resolution and aspect ratio
- Color space

Color space

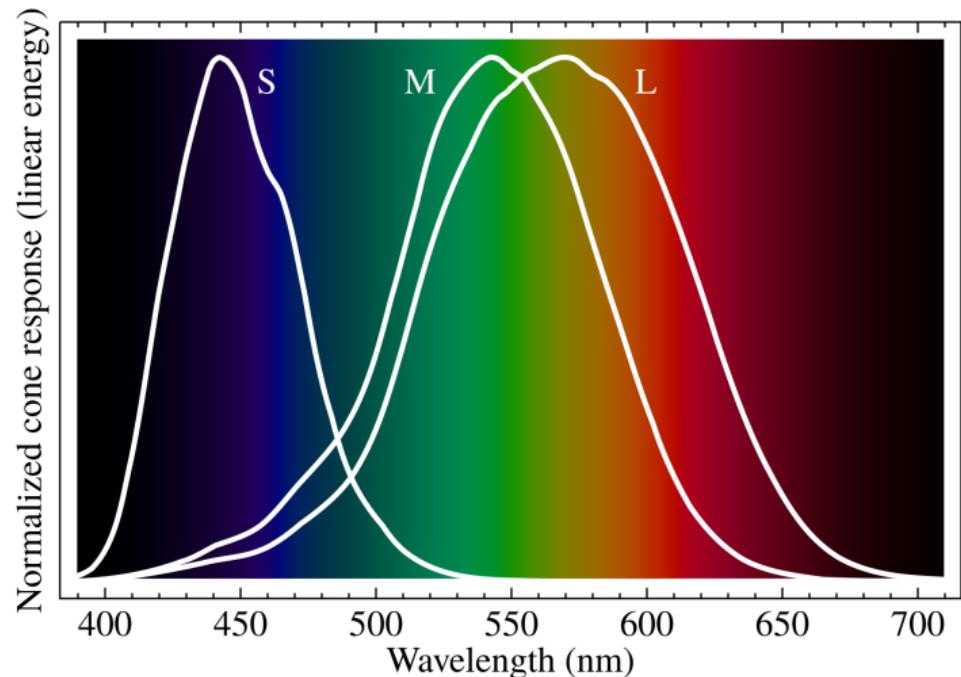


Figure: Normalized responsivity spectra of human cone cells

Color space

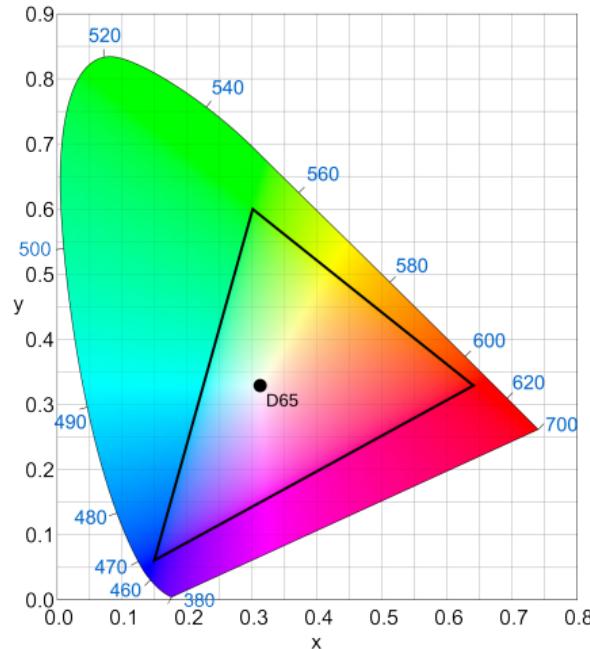


Figure: Rec.709 primaries and white point on the CIE 1931 x, y chromaticity diagram

Color space

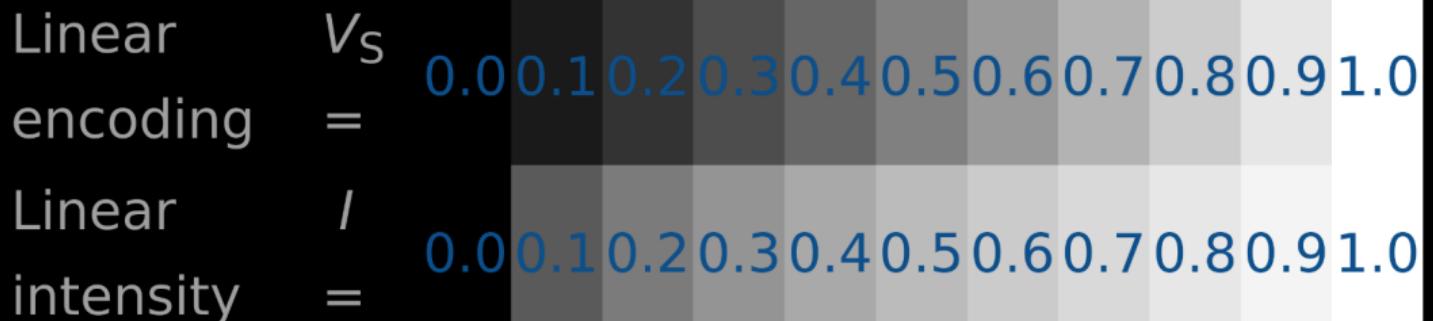


Figure: Gamma-encoded scale and linear-intensity scale

Resolution and aspect ratio

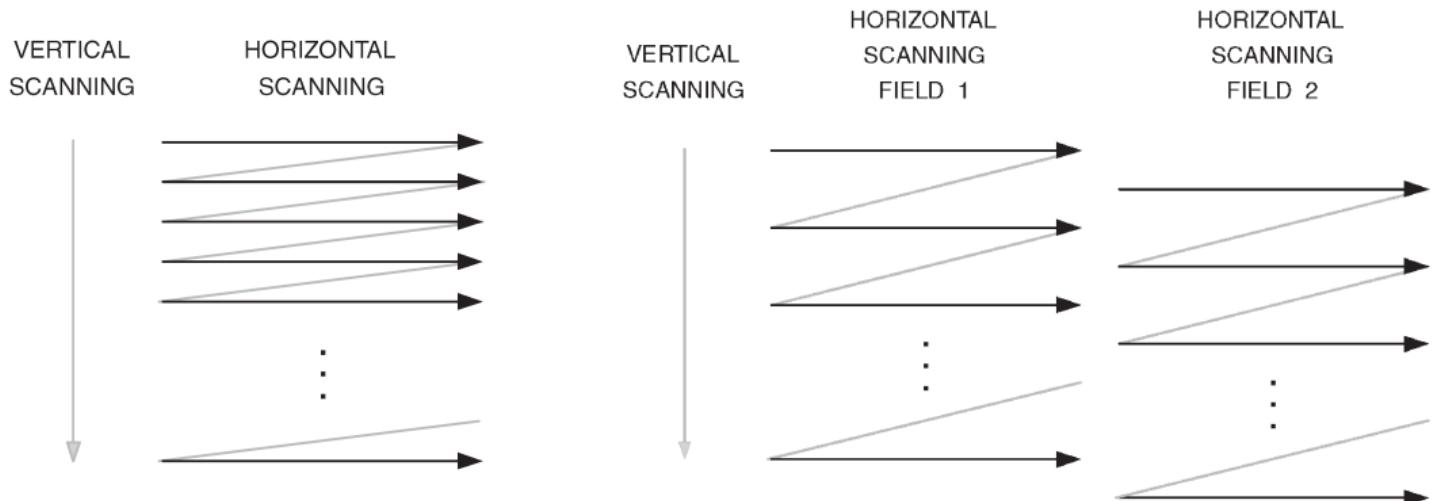


Figure: Progressive and interlaced scanning

Resolution and aspect ratio



Figure: A frame of a interlaced video on a progressive monitor

Quiz time!

Which one's video and audio quality is better, MP4, MKV or AVI?

Containers and codecs

Containers:

- Matroska (.mkv)
- MPEG-4 (.mp4)
- QuickTime (.mov)
- Ogg (.ogg)
- AVI (.avi)

Video codecs:

- AV1
- VP9
- HEVC (H.265)
- AVC (H.264)

Audio codecs:

- FLAC
- Opus
- AAC
- MP3

Video codec

- Intraframe compression
- Interframe compression

Video codec: Intraframe compression

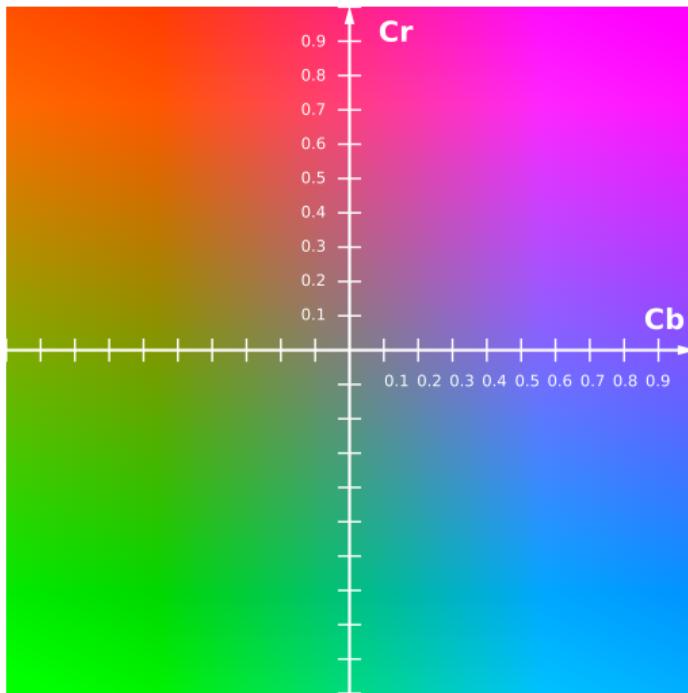


Figure: The Cb-Cr plane at $Y = 0.5$

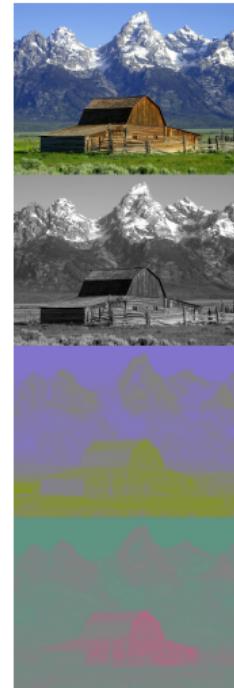


Figure: Y, Cb and Cr components of an image

Video codec: Intraframe compression



Photo from LGM by Manuel Schmalsteig CC-BY-2.0, Illusory Color Remix by Øyvind Kolås - <https://pippin.gimp.org/>

Figure: A black and white photo with illusory color remix

Video codec: Intraframe compression

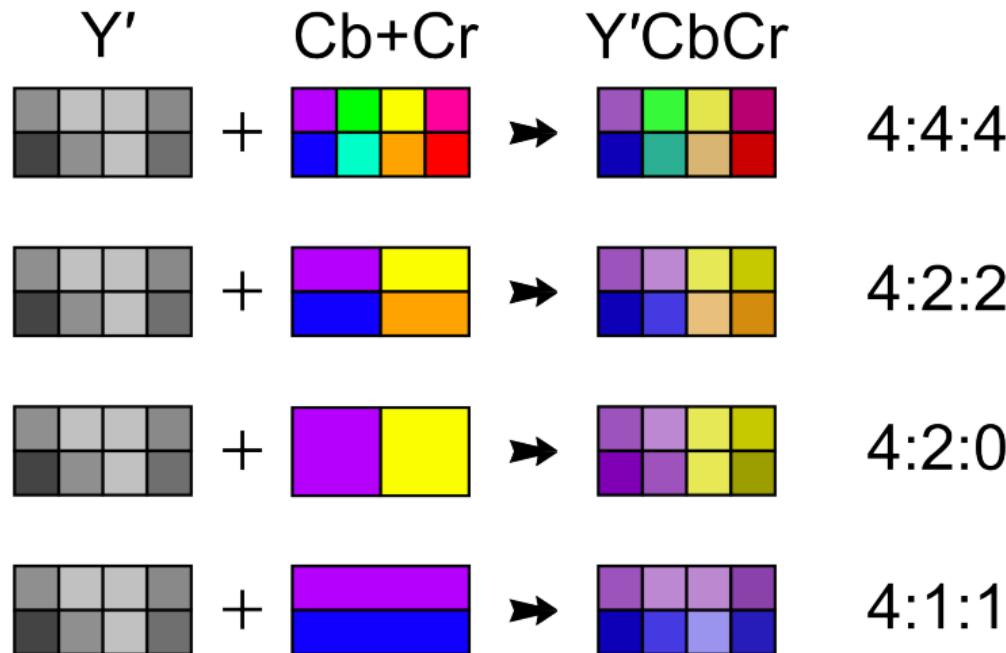


Figure: Common chroma subsampling schemes

Video codec: Intraframe compression



4:1:1



4:2:0



4:2:2



4:4:4



Figure: An image with different chroma subsampling schemes

Video codec: Intraframe compression

Chroma subsampling → Discrete cosine transform → Quantization
→ Filter → Entropy coding

[Figure](#): Common lossy intraframe compression method

Filter → Entropy coding

[Figure](#): Common lossless intraframe compression method

Video intraframe compression as image codec

- HEIF: HEVC
- AVIF: AV1
- WebP: VP8
- JPEG: MJPEG
- PNG: APNG
- GIF

Video codec: Interframe compression

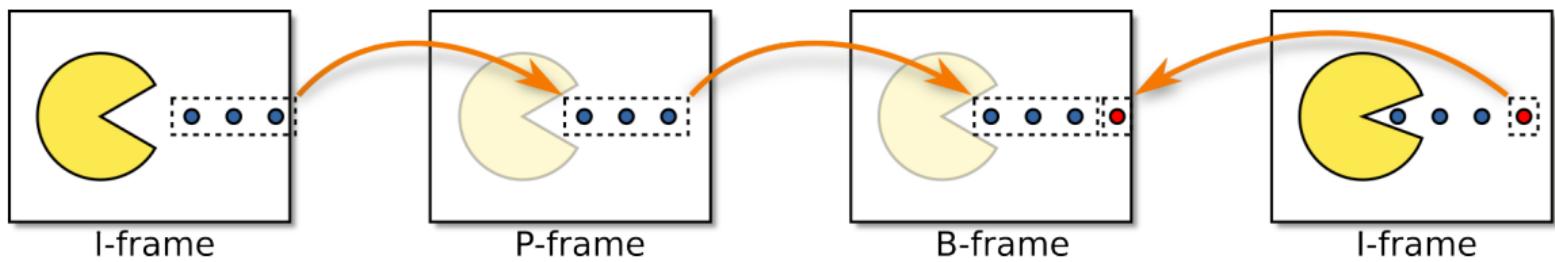


Figure: Keyframe (I), forward-predicted frame (P) and bi-directionally predicted frame (B)

Video codec: Interframe compression

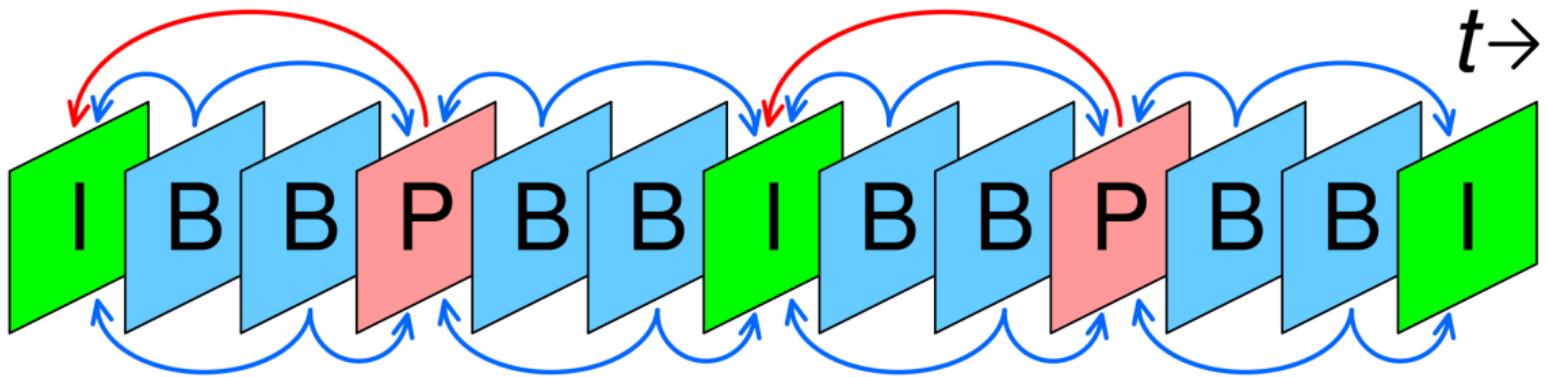
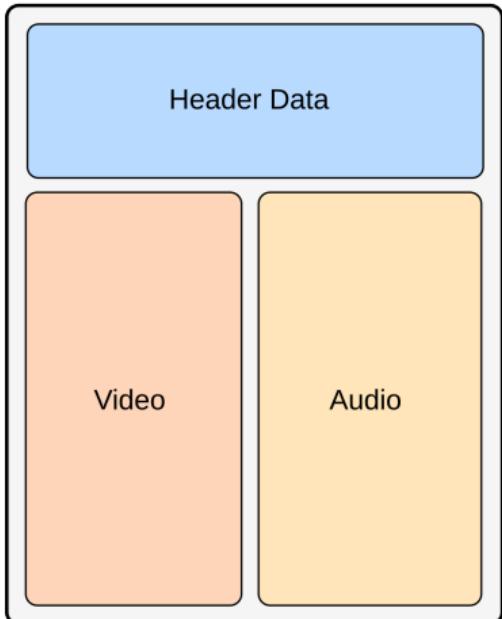


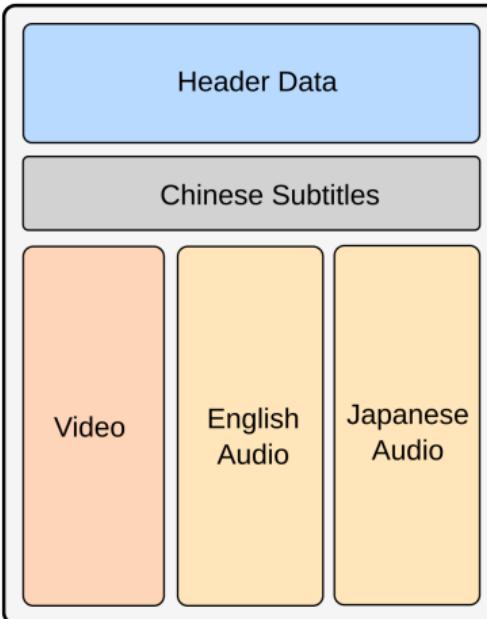
Figure: A group of pictures (GOP), I-frames are also instantaneous decoder refresh (IDR)

Container

AVI



Matroska



PDF

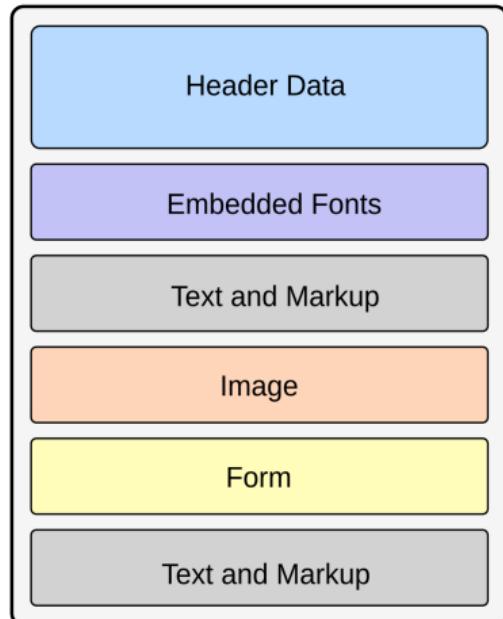


Figure: Sample structure of AVI, Matroska and PDF container

Real-world example with FFmpeg, ImageMagick and SQUOOSH.app

Real-world example with FFMPEG, IMAGEMAGICK and SQUOOSH.APP



Figure: Rickroll

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Thanks!