An Elementary Introduction to Media Codecs

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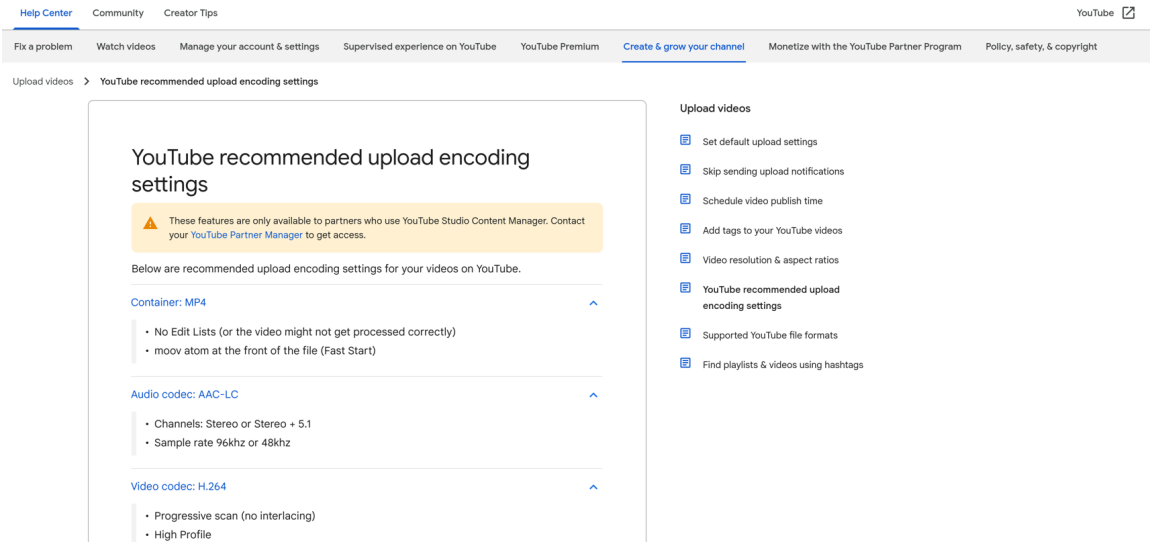
A real-world example of media codecs



YouTube recommended upload encoding settings

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

Color space

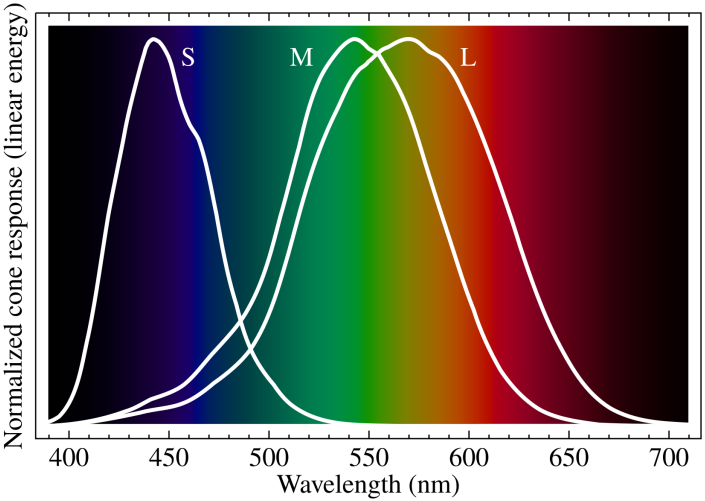


Figure: Normalized responsivity spectra of human cone cells

Color space

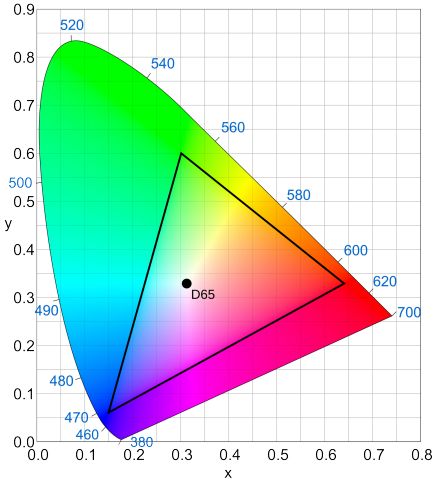


Figure: Rec.709 primaries and white point on the CIE 1931 x, y chromaticity diagram

Color space

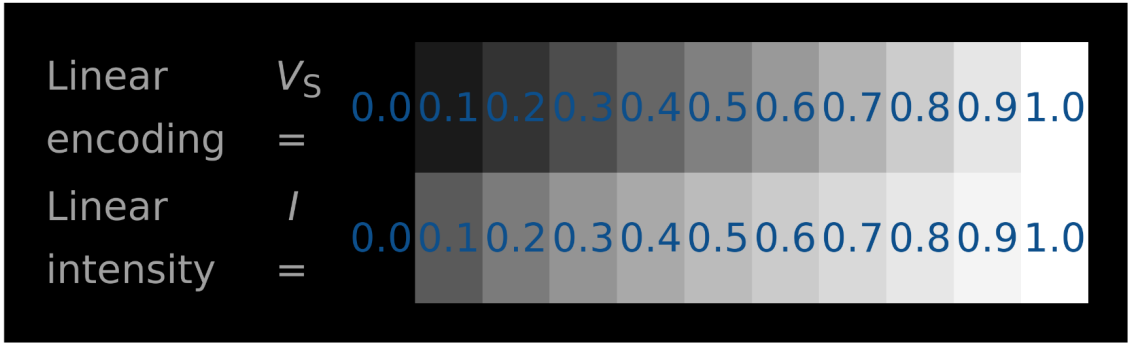


Figure: Gamma-encoded scale and linear-intensity scale

Resolution and aspect ratio

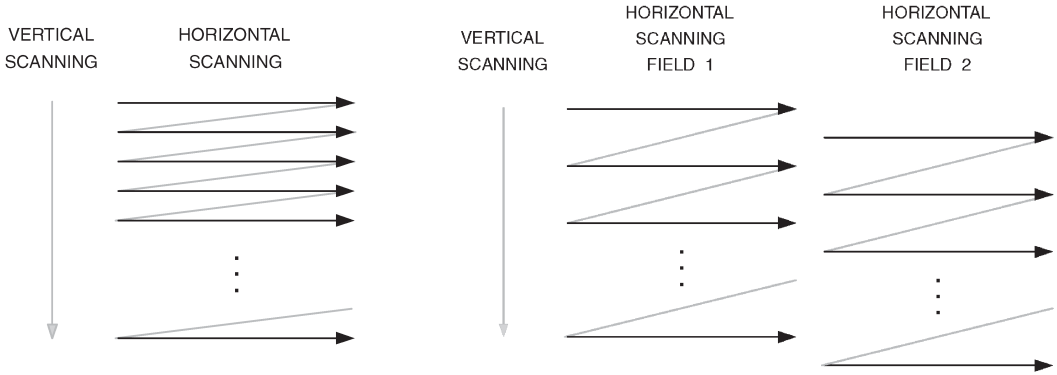


Figure: Progressive and interlaced scanning

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

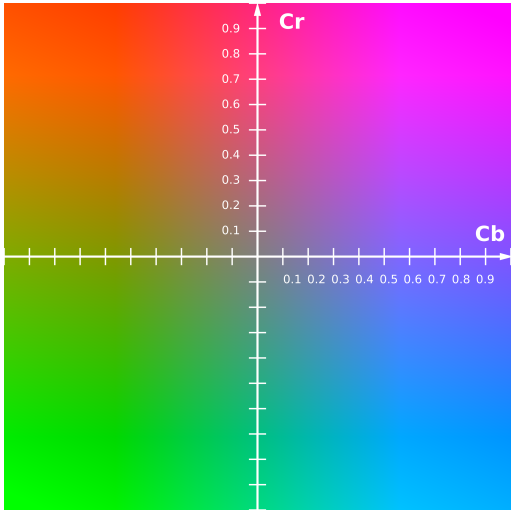


Figure: The Cb-Cr plane at Y $= 0.5$

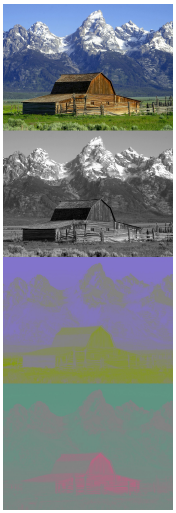


Figure: Y, Cb and Cr components of an image

Video codec: Intraframe compression

Figure: A black and white photo with illusory color remix

Video codec: Intraframe compression

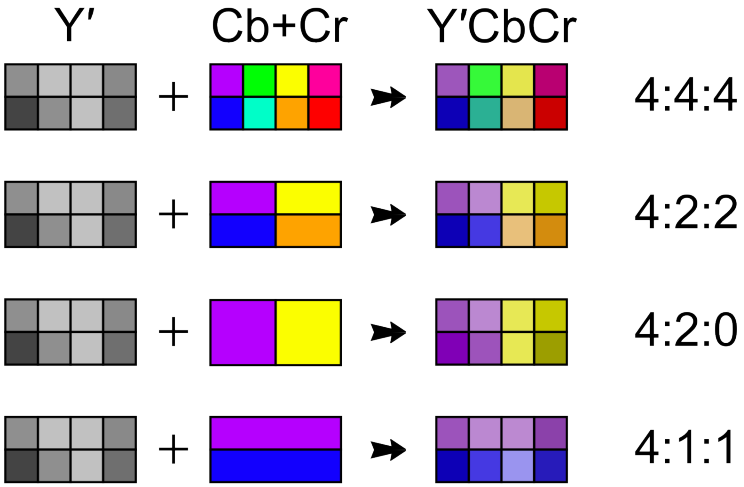


Figure: Common chroma subsampling schemes

Video codec: Intraframe compression

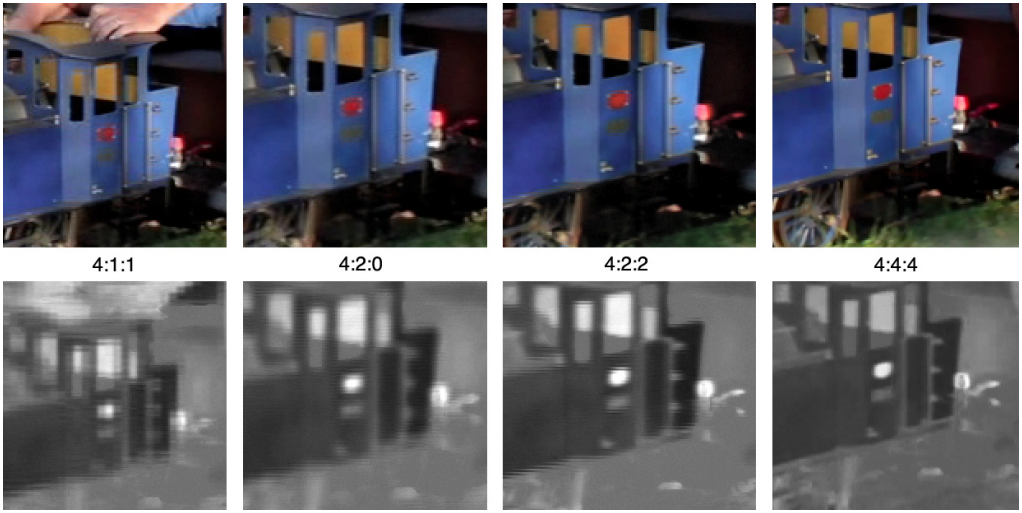


Figure: An image with different chroma subsampling schemes

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

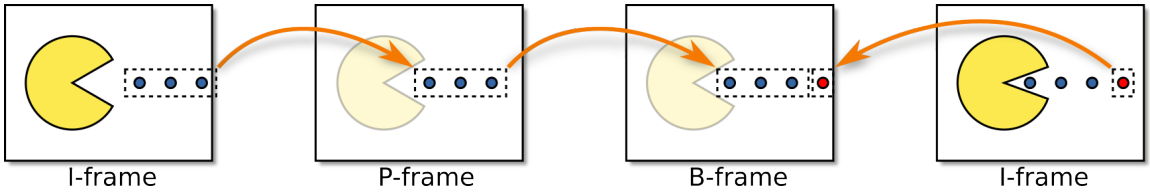


Figure: Keyframe (I), forward-predicted frame (P) and bi-directionally predicted frame (B)

Video codec: Interframe compression

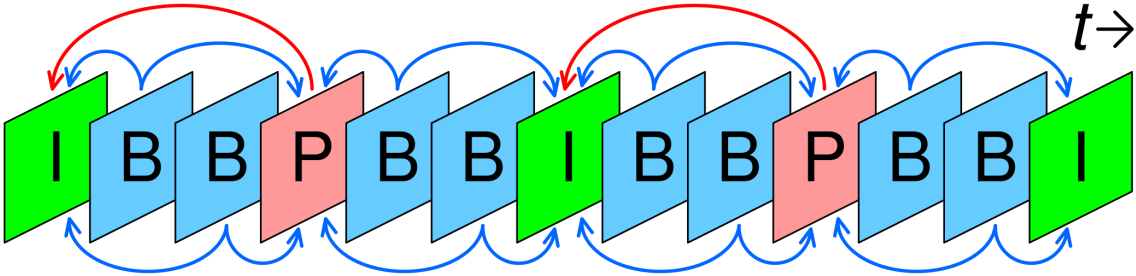


Figure: A group of pictures (GOP), I-frames are also instantaneous decoder refresh (IDR)

Container

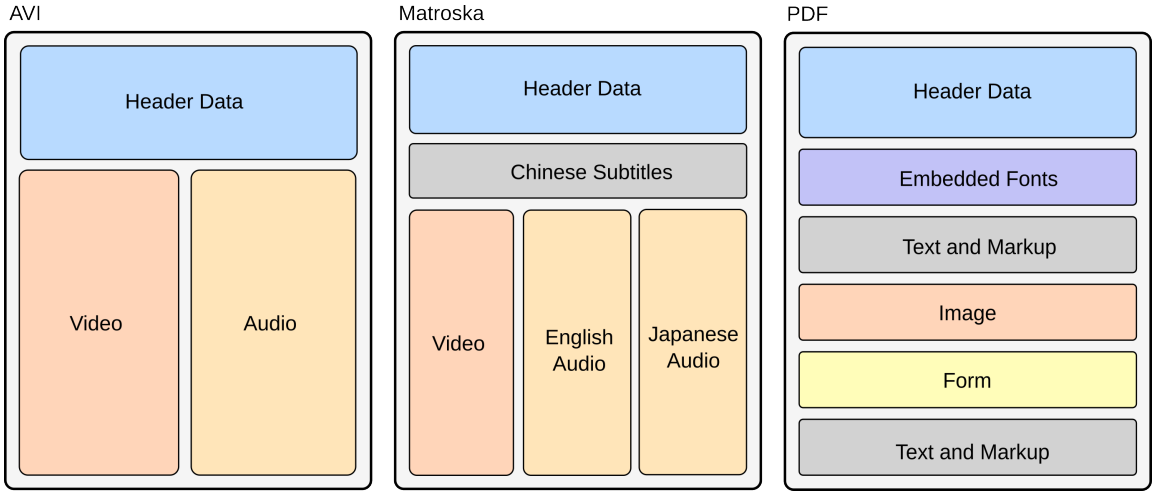


Figure: Sample structure of AVI, Matroska and PDF container

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

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Figure: Rickroll

Thanks!