

On Audio-Visual File Formats

Reto Kromer • AV Preservation by reto.ch

Hochschule der Künste Bern
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Summary

- digital audio and digital video
- container, codec, raw data
- different formats for different purposes
- audio-visual data transformations

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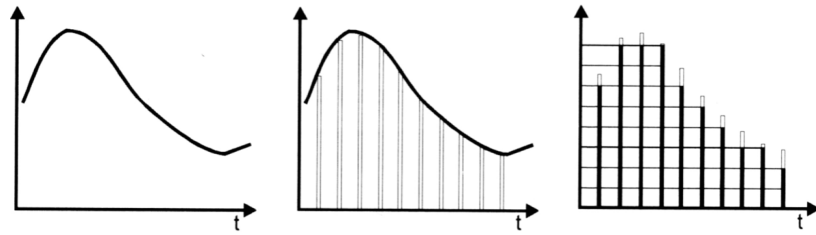
Digital Audio

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Digital Audio

- sampling
- quantisation

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digitisation = sampling + quantisation

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Sampling

- 44.1 kHz
- 48 kHz
- 96 kHz
- 192 kHz

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Quantisation

- 16 bit
- 24 bit
- 32 bit

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Digital Video

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Digital Video

- resolution
- bit depth
- linear, power, logarithmic
- colour model
- chroma subsampling
- illuminant

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Resolution

- SD 480i / SD 576i
- HD 720p / HD 1080i
- 2K / HD 1080p
- 4K / UHD-1
- 8K / UHD-2

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Bit Depth

- 8 bit
- 10 bit
- 12 bit
- 16 bit
- 24 bit

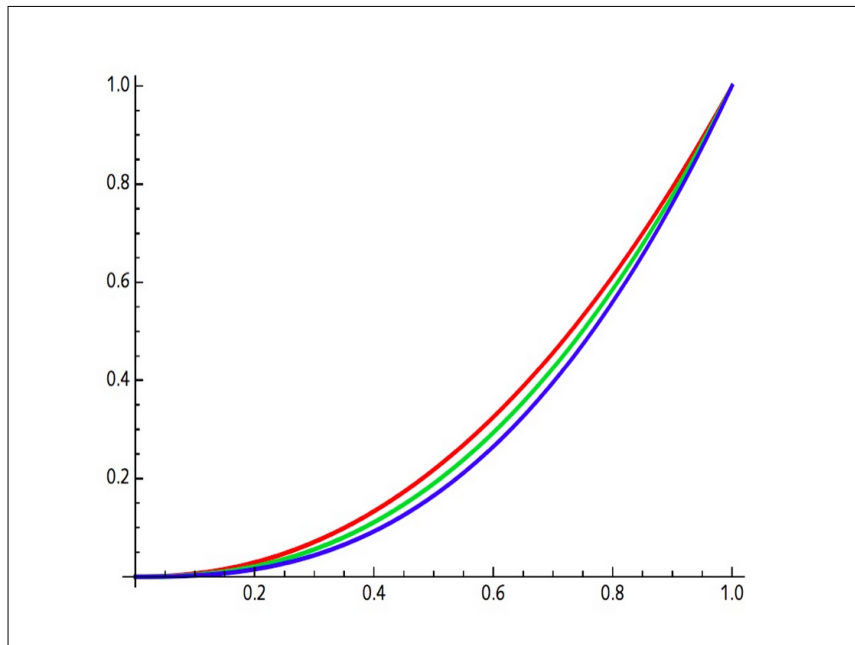
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Linear, Power, Logarithmic

«medium grey»

- linear: 18%
- «logarithmic»: 50%

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Colour Model

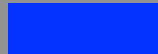
- XYZ
- RGB / R'G'B' / CMY / C'M'Y'
- Y'IQ / Y'UV / Y'D_BD_R
- Y'C_BC_R / Y'CoC_G
- Y'P_BP_R

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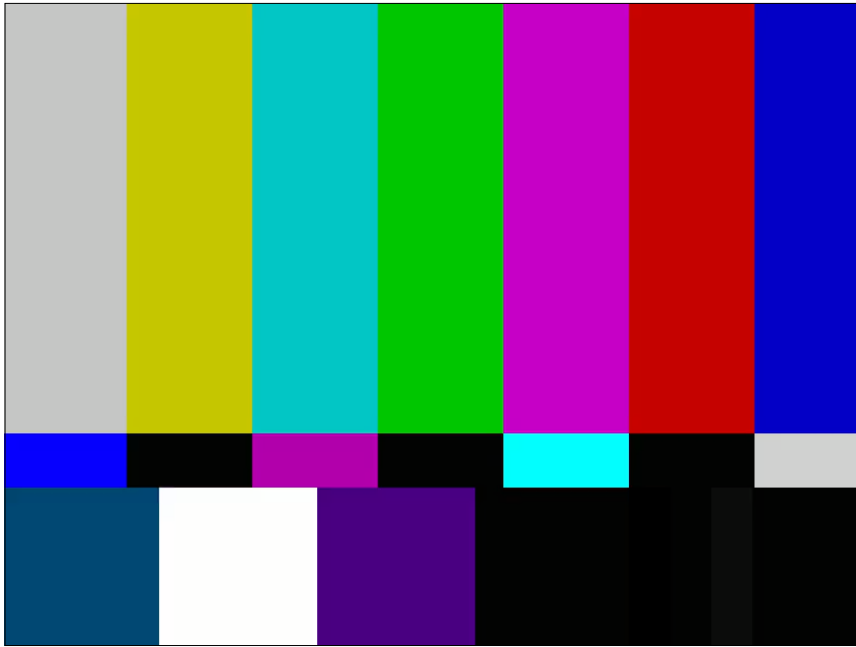


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RGB24

00000000	11111111	00000000	00000000
00000000	00000000	11111111	00000000
00000000	00000000	00000000	11111111
			
00000000	11111111	11111111	11111111
11111111	00000000	11111111	11111111
11111111	11111111	00000000	11111111
			

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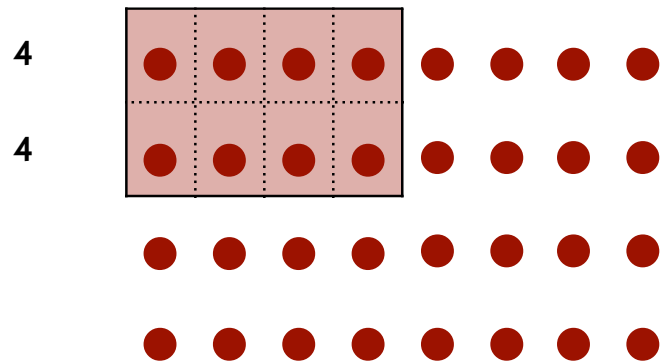
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Chroma Subsampling

- 4:4:4
- 4:2:2
- 4:2:0 / 4:1:1

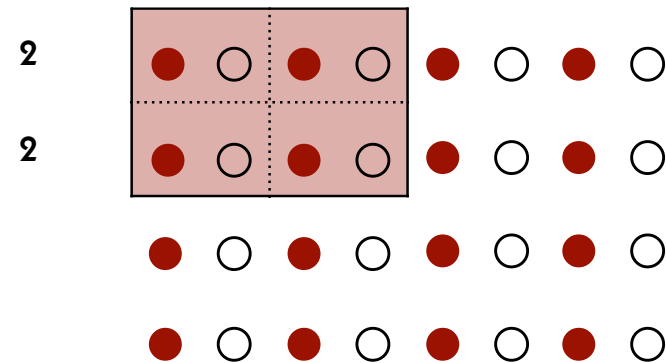
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4:4:4



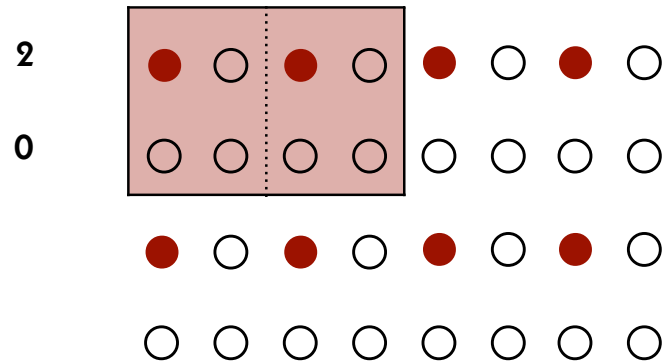
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4:2:2



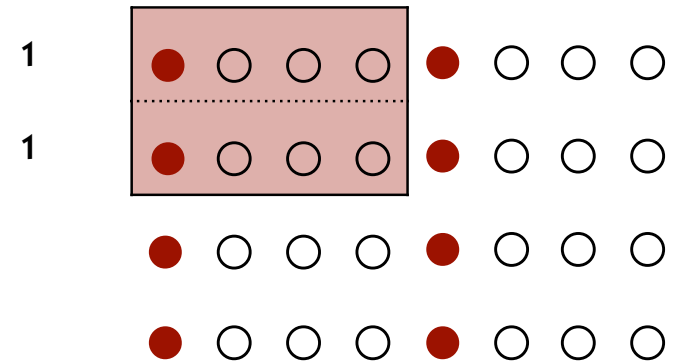
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4:2:0



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4:1:1

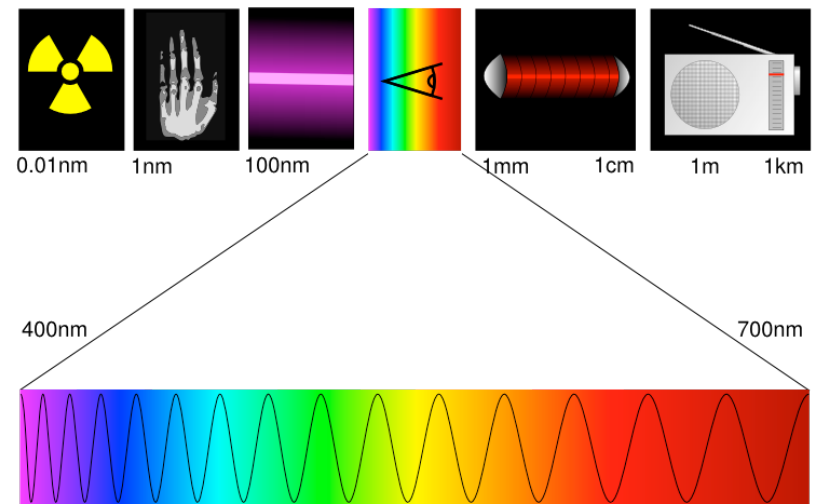


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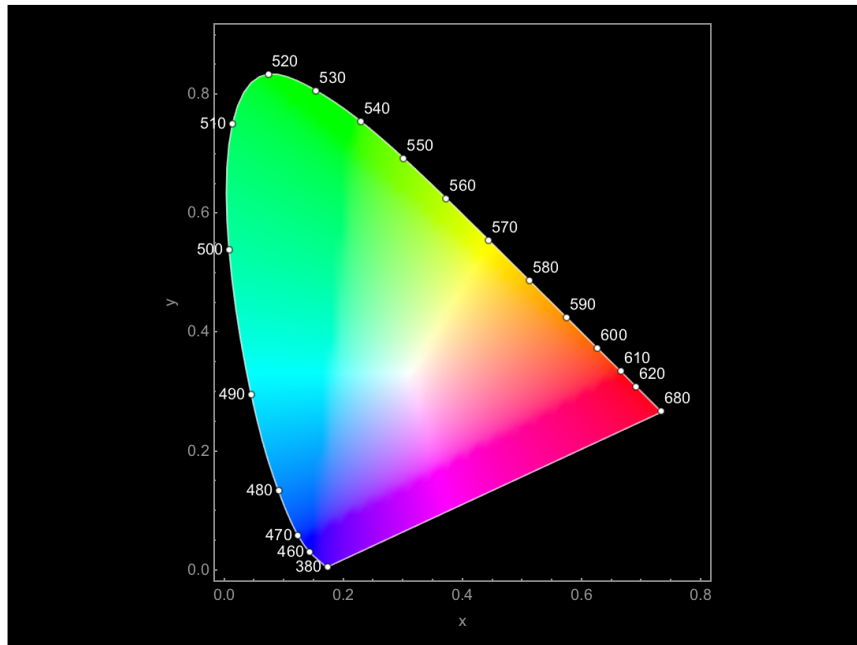
Illuminant

- D50
- D55
- D65
- D75

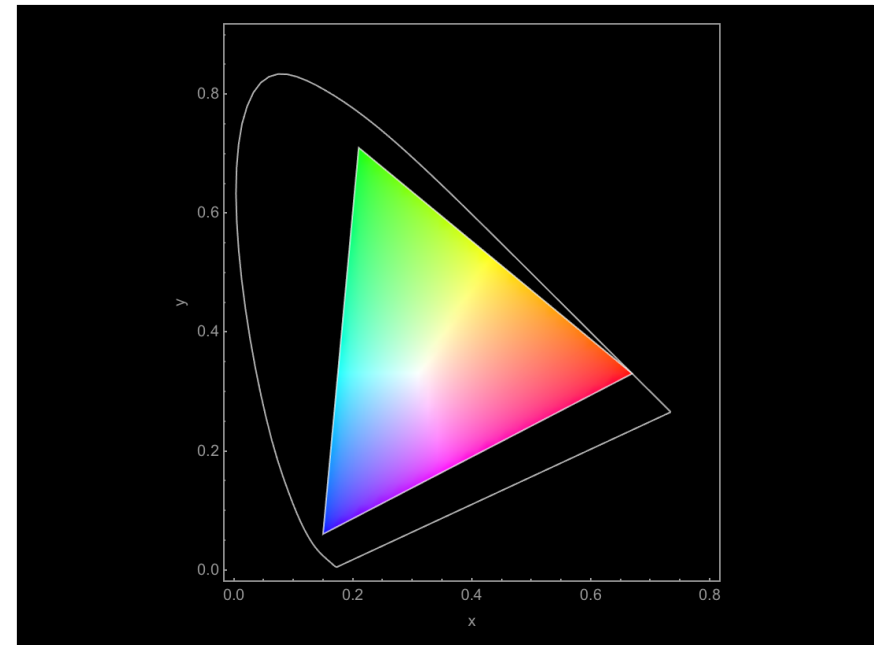
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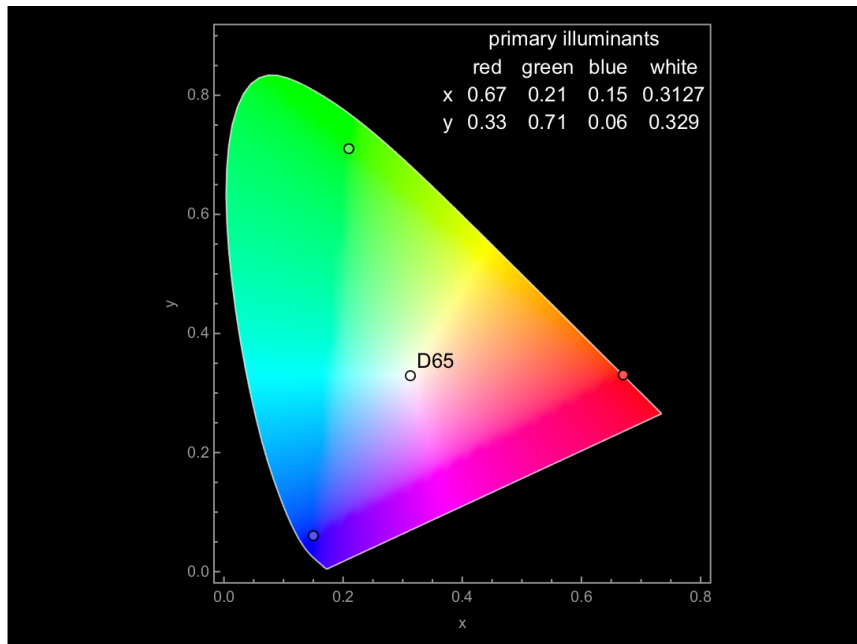
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File Structure

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```

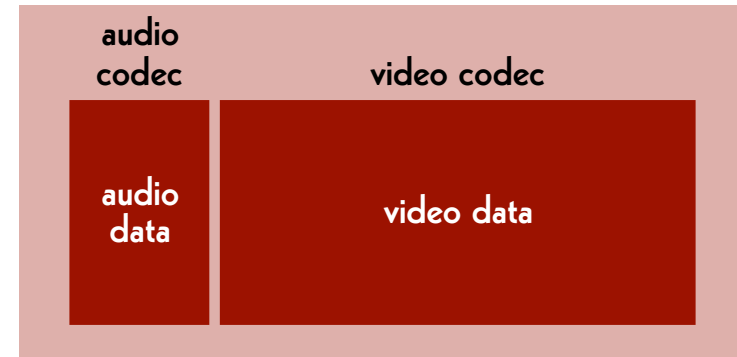
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1001011101010010101010001011010101
1110010101010101010000101110101010
0111010100101010100010110101011110
0101010101010101001101010100000001
00101000101010101010010101010101

```

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File Structure

audio-visual container (wrapper)



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Audio-Visual Container

- MP4
- MOV
- AVI
- MXF
- Matroska (.mkv)
- Flash

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Audio Codec

- WAVE
- AAC
- MP3
- BWF
- FLAC

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Video Codec

- H.264, H.265 (HEVC), AV1
- ProRes 422, ProRes 4444, ProRes RAW
- DNxHD, DNxHR
- CineForm RAW
- FFV1

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Data is anything
but «raw».

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Audio Data

- pcm_s16le
- pcm_s24le
- pcm_s32le

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Video Data

- | | |
|------------------|---------------|
| • rgb48le | • yuv444p16le |
| • rgb24 | • yuv422p10le |
| • rgb72le | • uyvy422 |
| | • yuv420p |
| | • yuv444p24le |
| • bayer_bggr16le | |
| • bayer_bggr24le | |

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«Single-Image Codec»

- TIFF
- DPX
- JPEG 2000
- OpenEXR
- DNG
- FFV1

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«Single-Image Container»

- folder
- TAR
- ZIP
- CinemaDNG
- MXF
- Motion JPEG
- Matroska (.mkv)

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What is inside my DPX?

- log neg encoding
- log RGB encoding or quasi-log encoding
- gamma encoding or power function encoding
- scene-linear encoding

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File Formats

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Principles

- **The archive must be able to handle the file formats it holds.**
- open source
- simple to use and well documented
- widely used by the community

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Different Purposes

archive master format:

→ for preservation

mezzanine format:

→ for professional use in post-production

dissemination formats:

→ for widely spreading and easy access

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Elena Rossi-Snook:

**Archiving without access
isn't preservation,
it's hoarding.**

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Archive Master (Today)

film

- folder, TIFF, 2K, RGB, 4:4:4, 16 bit
- MXF, DPX, 2K, R'G'B', 4:4:4, 10 bit

video

- AVI, «raw», HD, Y'CbCr, 4:2:2, 10 bit
- Matroska, FFV1, HD, Y'CbCr, 4:2:2, 10 bit

audio

- BWF, 96 kHz, 24 bit
- FLAC, 96 kHz, 24 bit

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Mezzanine (Today)

video

- ProRes 4444, 2K
- DNxHR, 2K
- ProRes 422 HQ, HD
- DNxHD 175x, HD

audio

- BWF, 48 kHz, 24 bit
- WAVE, 48 kHz, 24 bit

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Dissemination (Today)

MP4

Video

- H.264, SD, yuv420p, «lossy»
- H.264, HD, yuv420p, «lossy»

Sound

- AAC, 44.1 kHz, 16 bit
- AAC, 48 kHz, 16 bit

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Archive Master and Mezzanine

film

- Matroska, FFV1, 2K, «RGB», 4:4:4, 16 bit

video

- Matroska, FFV1, HD, Y'C_BC_R, 4:2:2, 10 bit

audio

- Matroska, FLAC, 96 kHz, 24 bit

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Access

WebM (a subset of Matroska)

Video

- «H.265», HD, yuv420p

Sound

- «FLAC», 48 kHz, 16 bit

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Reading

Reto Kromer: **Matroska and FFV1: One File Format for Film and Video Archiving?**, in «Journal of Film Preservation», n. 96 (April 2017), FIAF, Brussels, Belgium, p. 41–45

→ https://retokromer.ch/publications/JFP_96.html

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Pros & Cons

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container:

- folder
- TAR
- ZIP
- MXF
- Matroska
- AXF

codec:

- Cineon, DPX
- TIFF [TI/A?]
- JPEG 2000
- FFV1
- OpenEXR
- CineForm RAW
- ProRes RAW

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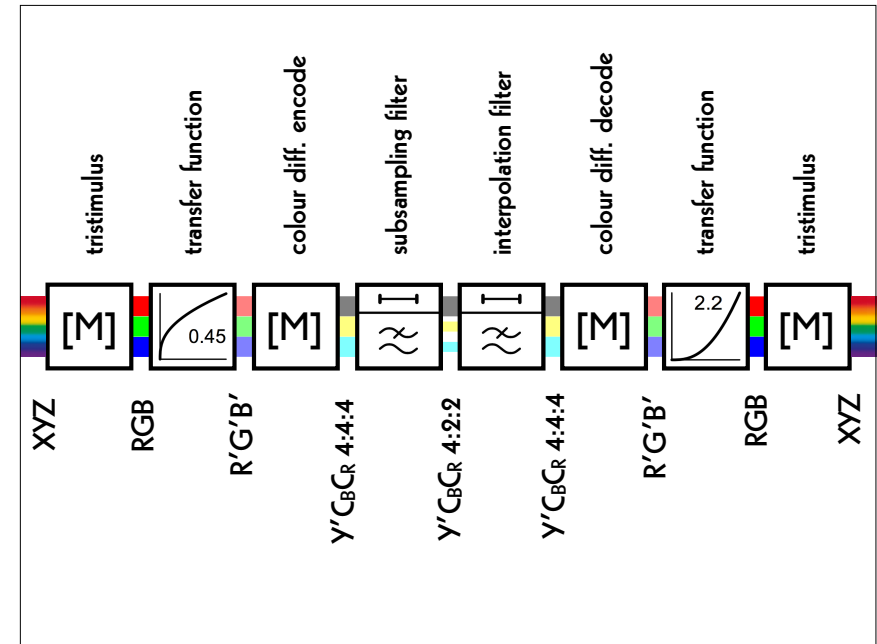
Transformations

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$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1.140251 \\ 1 & -0.393931 & -0.580809 \\ 1 & 2.028398 & 0 \end{bmatrix} \cdot \begin{bmatrix} Y'_{601} \\ U \\ V \end{bmatrix}$$

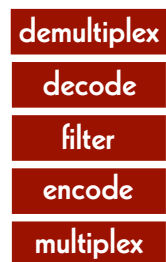
$$\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} = \begin{bmatrix} 1 & 0.956295 & 0.621025 \\ 1 & -0.272558 & -0.646709 \\ 1 & -1.104744 & 1.701157 \end{bmatrix} \cdot \begin{bmatrix} Y'_{601} \\ I \\ Q \end{bmatrix}$$

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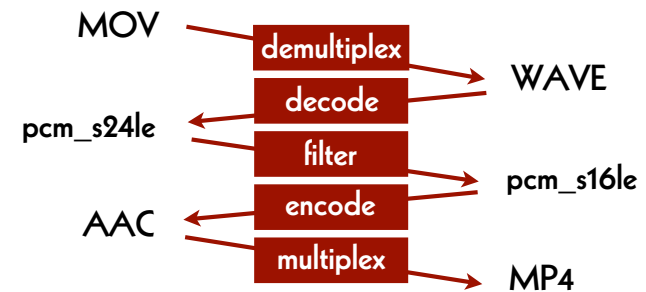
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Data Transformations



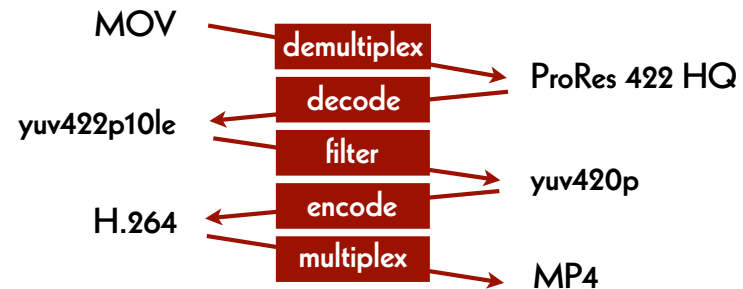
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Audio Exemple



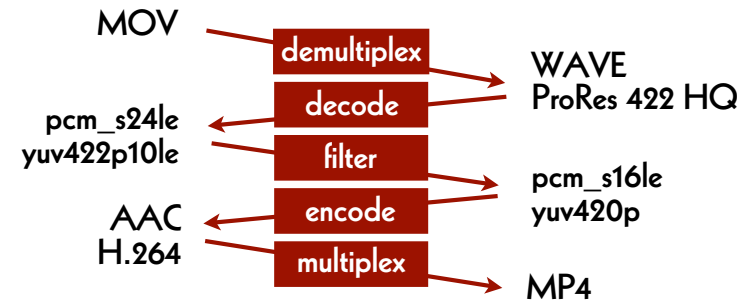
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Video Exemple



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Audio-Visual Exemple



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- Agathe Jarczyk & David Pfluger

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AV Preservation by reto.ch

chemin du Suchet 5
1024 Écublens
Switzerland

Web: reto.ch
Twitter: @retoch
Email: info@reto.ch



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