

On Audio-Visual File Formats

Reto Kromer • AV Preservation by reto.ch

Migration von Film- und Videodaten
Lichtspiel, Bern, 31. Oktober 2018

1

Summary

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

2

Digital Audio

3

Digital Audio

- sampling
- quantisation

4

Sampling

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

6

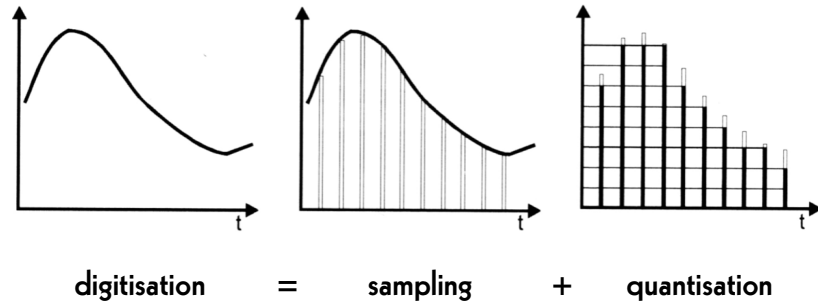
Quantisation

- 16 bit
- 24 bit
- 32 bit

7

Digital Video

8



5

Digital Video

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

9

Resolution

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

10

Bit Depth

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

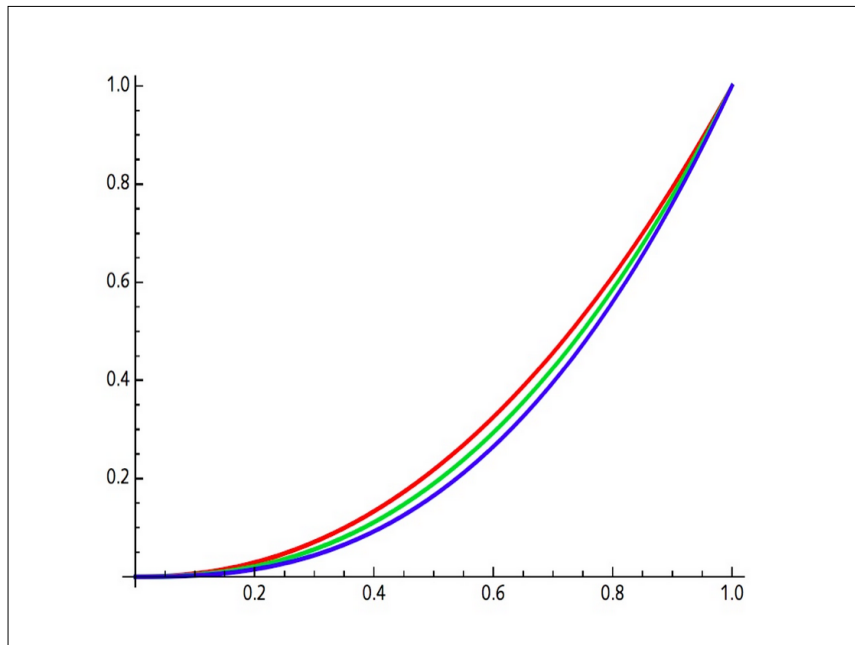
11

Linear, Power, Logarithmic

«medium grey»

- linear: 18%
- «logarithmic»: 50%

12



13

Colour Model

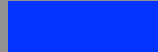
- XYZ
- RGB / R'G'B' / CMY / C'M'Y'
- Y'IQ / Y'UV / Y'D_BD_R
- Y'C_BC_R / Y'CoC_G
- Y'P_BP_R

14

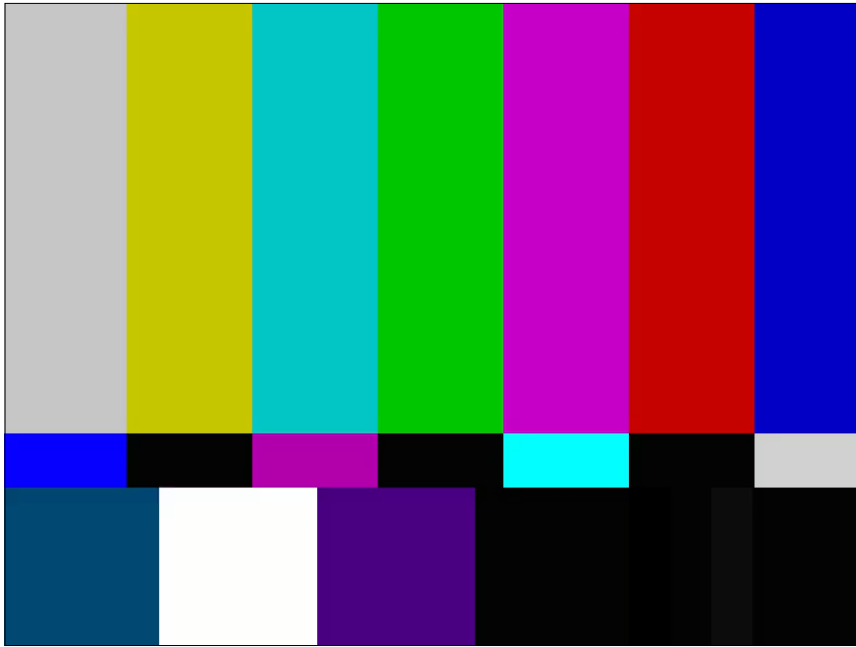


15

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
			

16



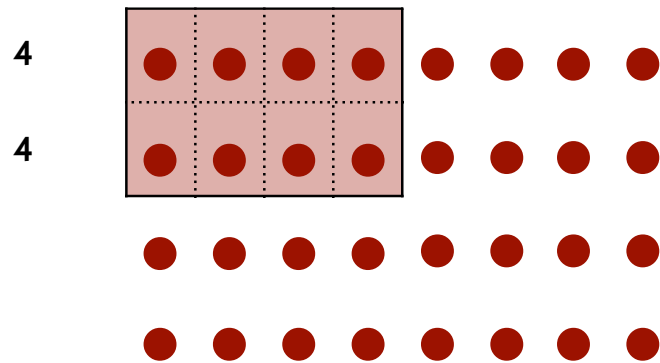
17

Chroma Subsampling

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

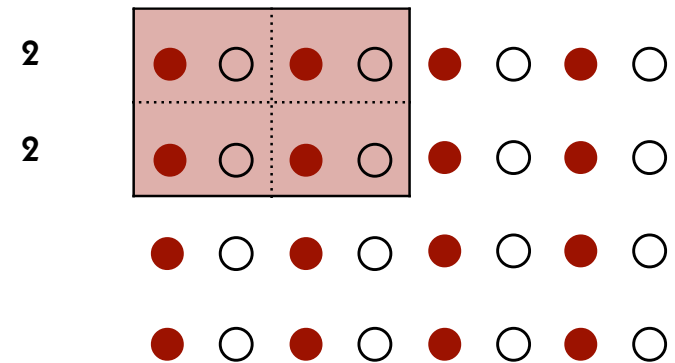
18

4:4:4



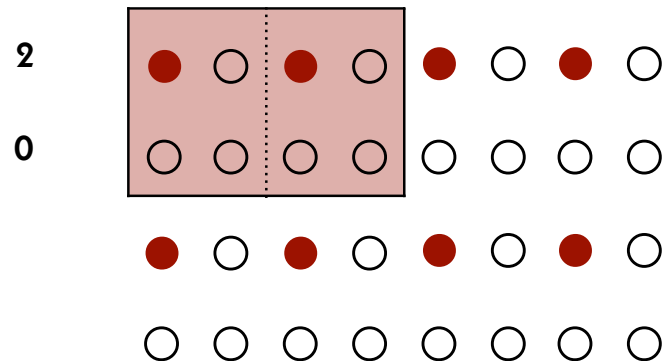
19

4:2:2



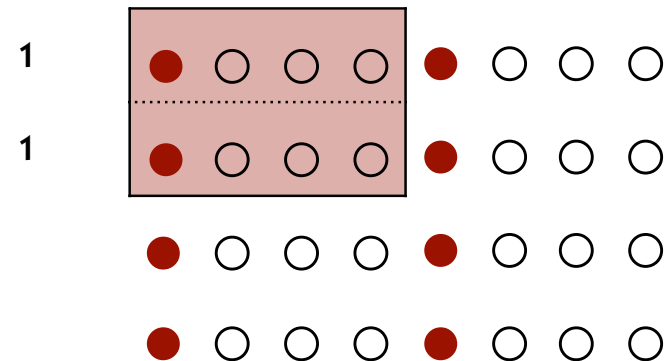
20

4:2:0



21

4:1:1

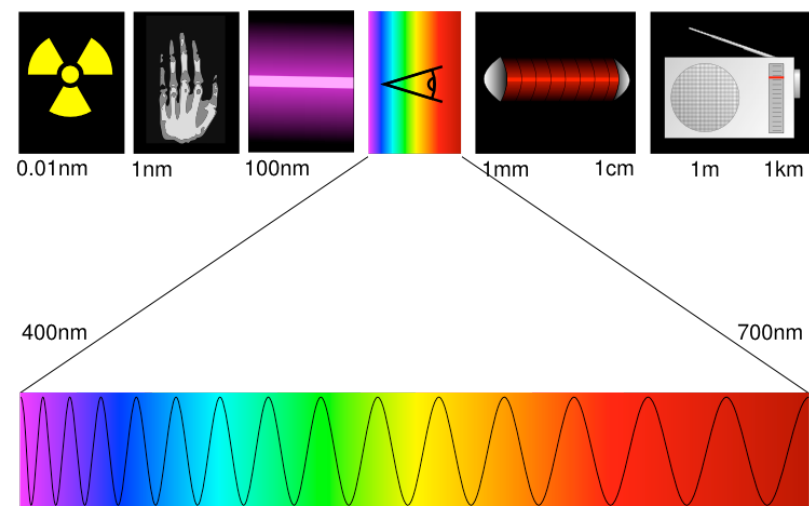


22

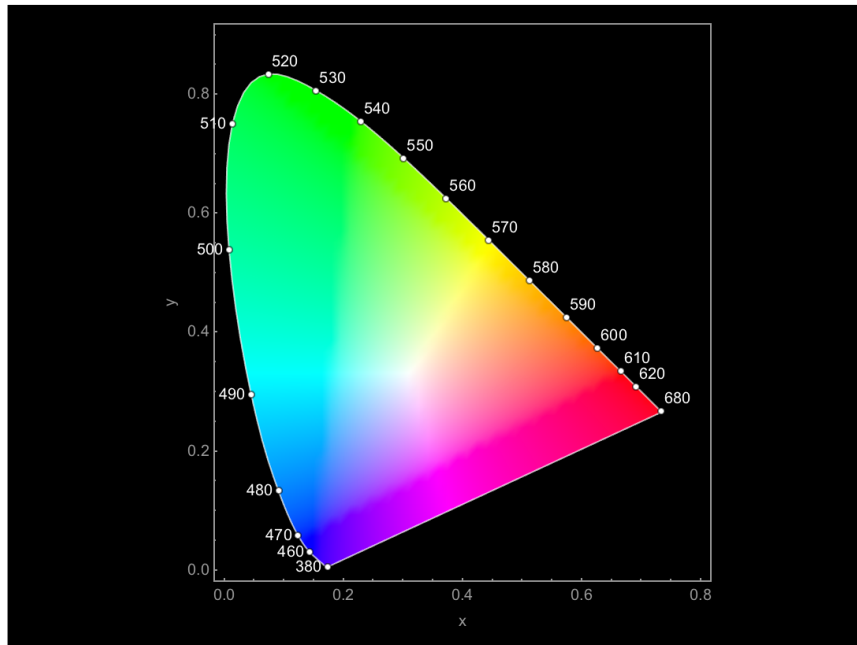
Illuminant

- D50
- D55
- D65
- D75

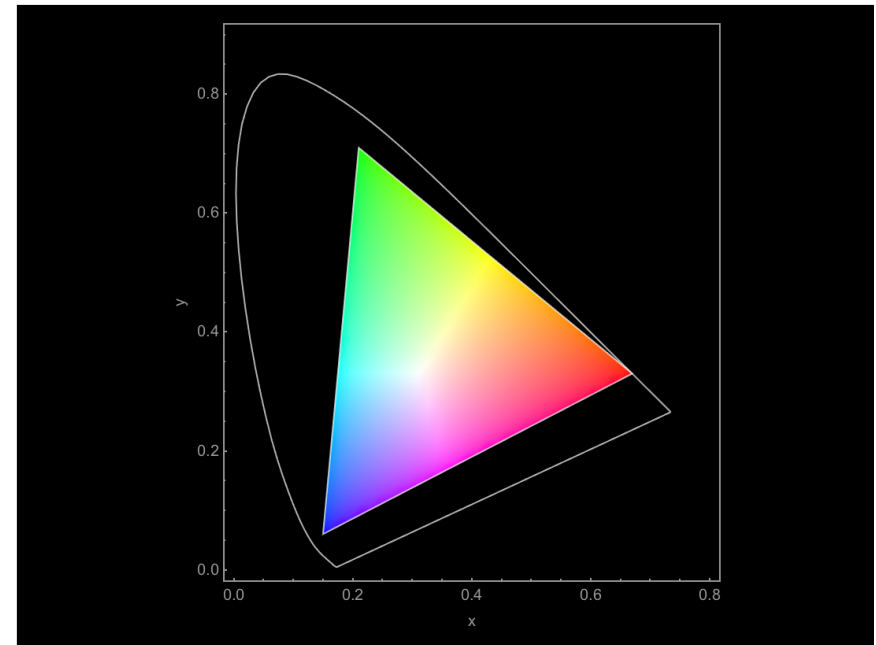
23



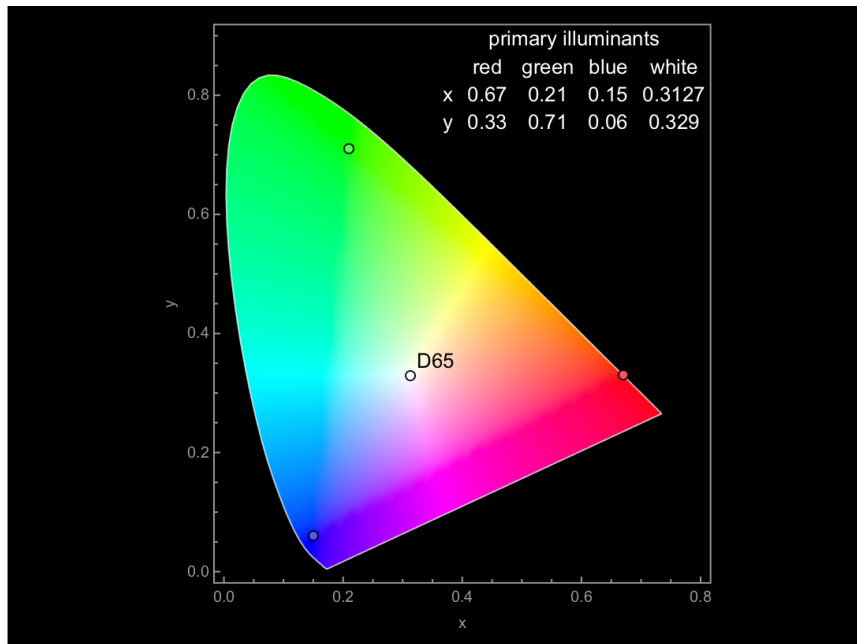
24



25



26



27

File Structure

28

```

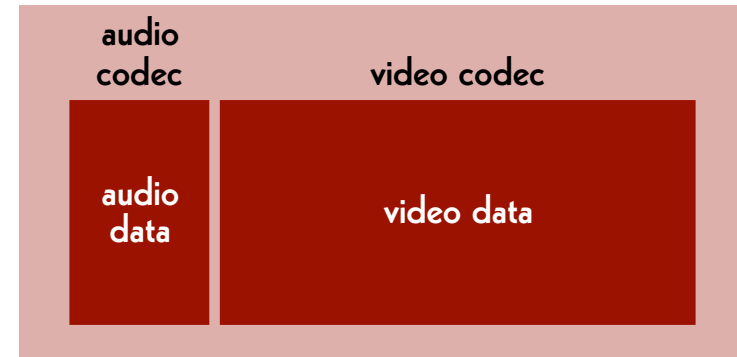
0111010100101010100010110101011110
0100110101010101010100001011101010
0111010100101010100010110101011110
0001110101010101010100001011101010
0110101010010101010001011010101111
001010101010101010000101110101010000
0111010100101010100010110101011110
010101010101010101000010111010100110
1001011101010010101010001011010101
1110010101010101010000101110101010
0111010100101010100010110101011110
0101010101010101001101010100000001
00101000101010101010010101010101

```

29

File Structure

audio-visual container (wrapper)



30

Audio-Visual Container

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

31

Audio Codec

- WAVE
- BWF
- FLAC
- AAC
- MP3

32

Video Codec

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

33

Data is anything
but «raw».

34

Audio Data

- pcm_s16le
- pcm_s24le
- pcm_s32le

35

Video Data

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

36

«Single-Image Codec»

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

37

«Single-Image Container»

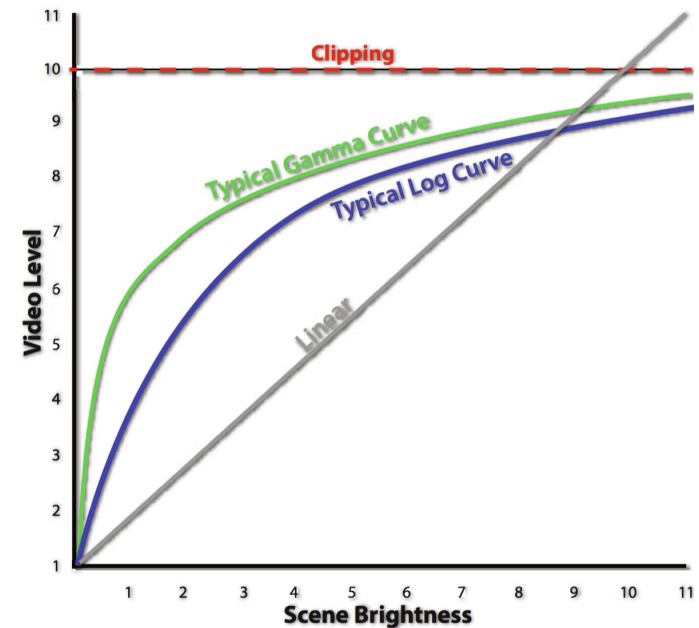
- folder
- TAR
- ZIP
- CinemaDNG
- MXF
- Motion JPEG
- Matroska (.mkv)

38

What is inside my DPX?

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

39



40

File Formats

41

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

42

Different Purposes

archive master format:

→ for preservation

mezzanine format:

→ for professional use in post-production

dissemination formats:

→ for widely spreading and easy access

43

Elena Rossi-Snook:

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

44

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

audio

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

45

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

46

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

47

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

48

Access

WebM (a subset of Matroska)

Video

- «H.265», HD, yuv420p

Sound

- «FLAC», 48 kHz, 16 bit

49

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

50

Pros & Cons

51

container:

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

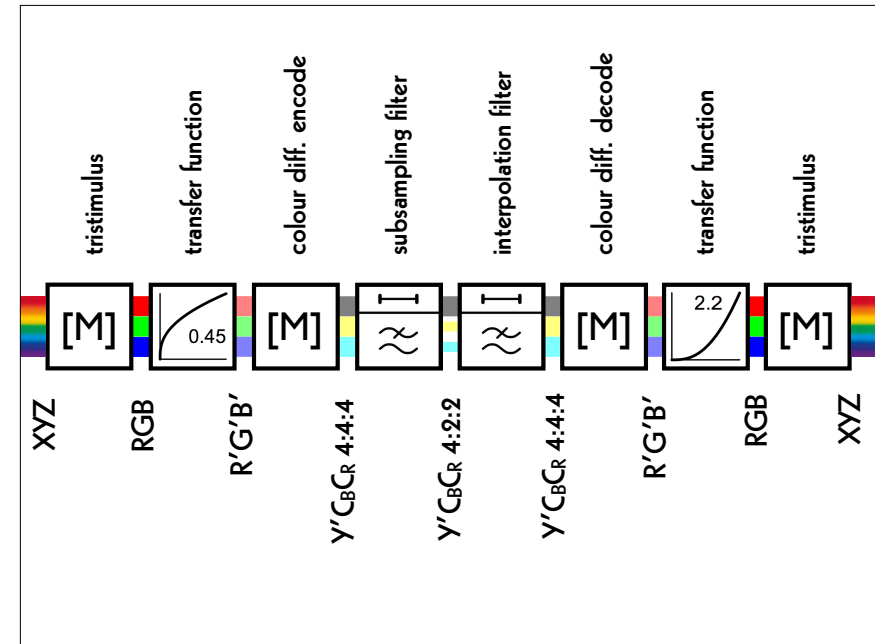
codec:

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

52

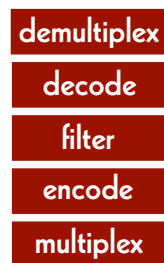
Transformations

53



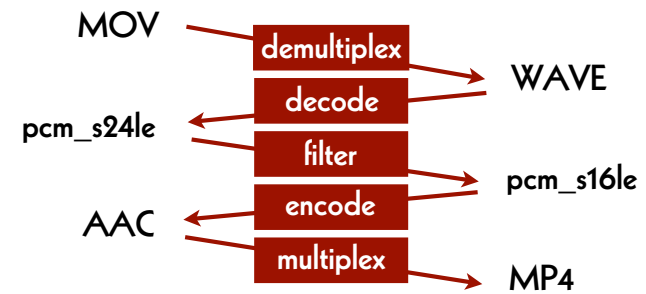
54

Data Transformations



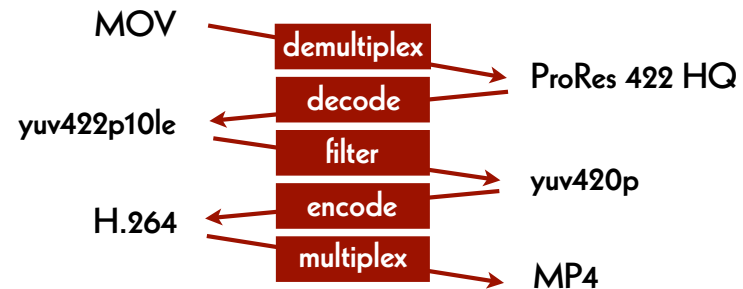
55

Audio Exemple



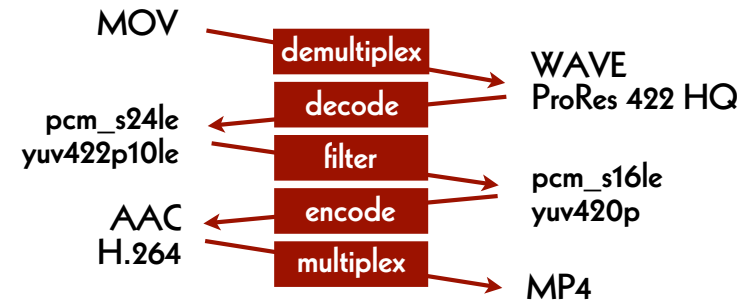
56

Video Exemple



57

Audio-Visual Exemple



58

Acknowledgements

- Swiss Federal Institute of Technology
- Massachusetts Institute of Technology
- Kinemathek Lichtspiel, Bern
- Charles Poynton
- Dave Rice & Misty De Meo
- Agathe Jarczyk & David Pfluger

59

AV Preservation by reto.ch

chemin du Suchet 5
1024 Écublens
Switzerland

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



60