

# On Audio-Visual File Formats

Reto Kromer • AV Preservation by reto.ch

**L'eredità ritrovata**  
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1

## Summary

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

2

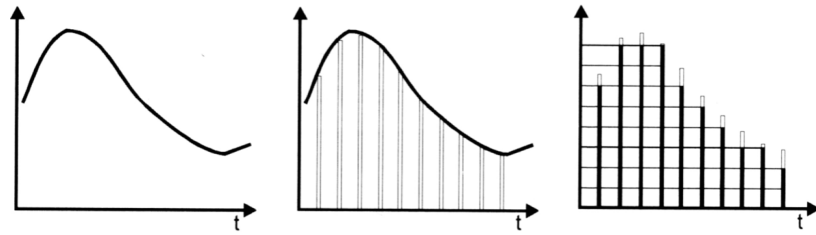
# Digital Audio

3

## Digital Audio

- sampling
- quantisation

4



digitisation = sampling + quantisation

5

## Sampling

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

6

## Quantisation

- 16 bit
- 24 bit
- 32 bit

7

# Digital Video

8

## 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

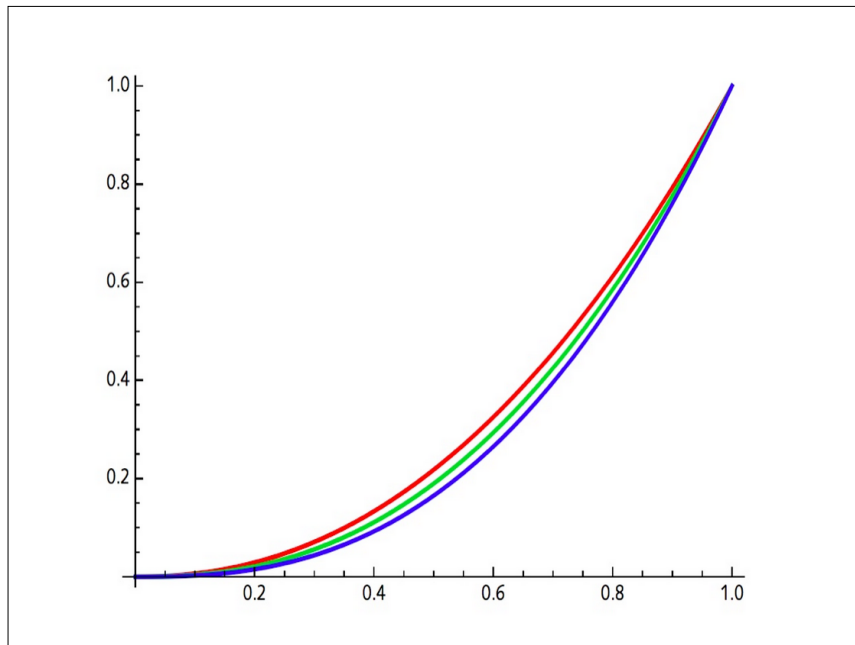
11

## Linear, Power, Logarithmic

«medium grey»

- linear: 18%
- «logarithmic»: 50%

12



13

## Colour Model

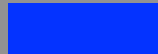
- XYZ
- RGB / R'G'B' / CMY / C'M'Y'
- Y'IQ / Y'UV / Y'D<sub>B</sub>D<sub>R</sub>
- Y'C<sub>B</sub>C<sub>R</sub> / Y'CoC<sub>G</sub>
- Y'P<sub>B</sub>P<sub>R</sub>

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



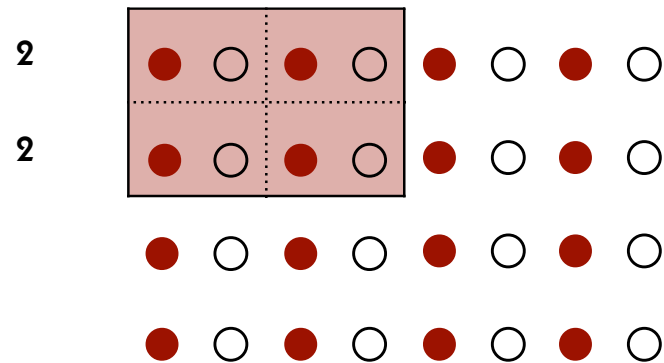
17

## Chroma Subsampling

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

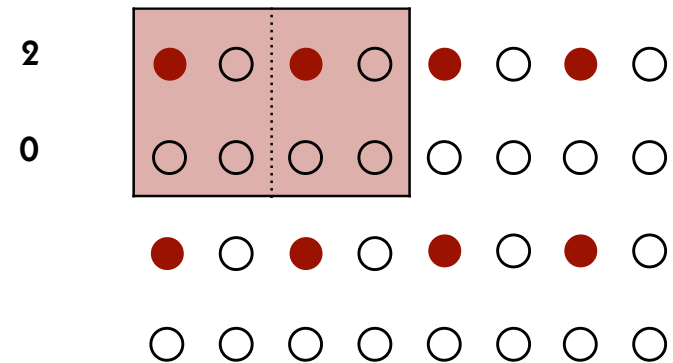
18

### 4:2:2



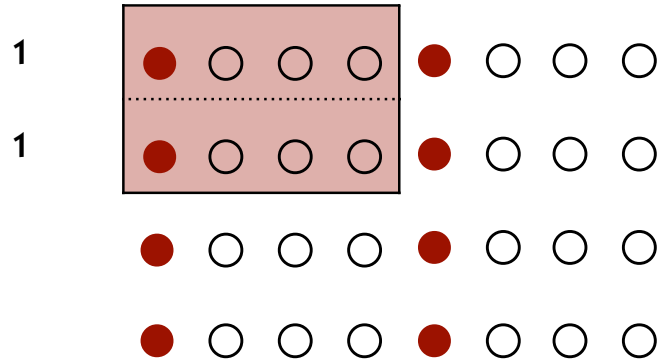
19

### 4:2:0



20

4:1:1

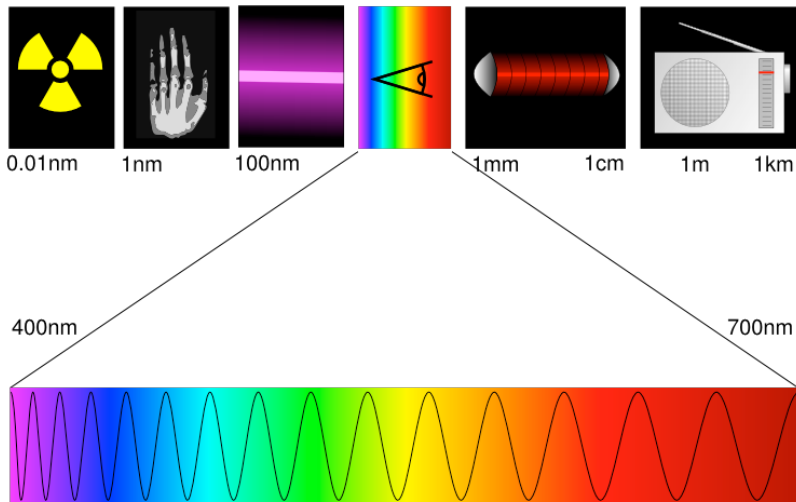


21

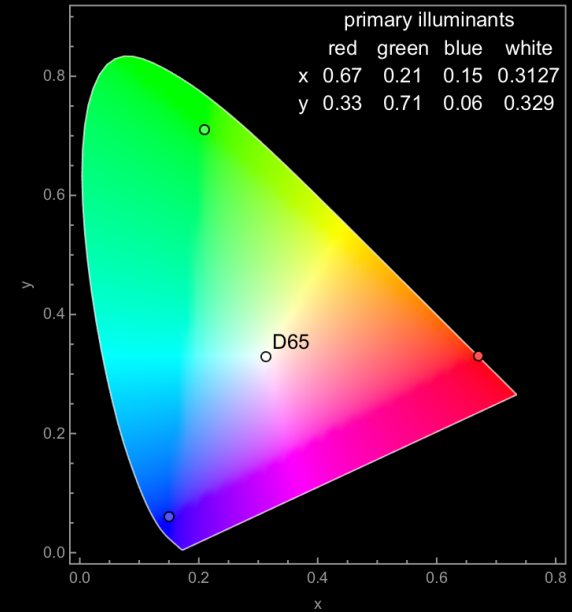
Illuminant

- D50
- D55
- D65
- D75

22



23



24

# File Structure

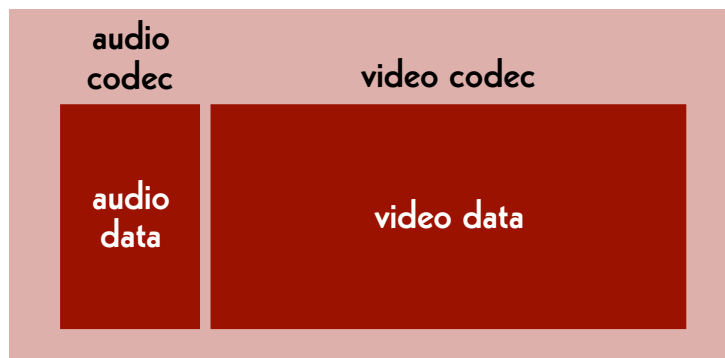
25

```
0111010100101010100010110101011110
010011010101010101010100001011101010
0111010100101010100010110101011110
000111010101010101010100001011101010
0110101010010101010100010111010101111
001010101010101010000101110101010000
0111010100101010100010110101011110
010101010101010101000010111010100110
1001011101010010101010001011010101
1110010101010101010000101110101010
0111010100101010100010110101011110
0101010101010101001101010100000001
0010100010101010101001010101010101
```

26

## File Structure

audio-visual container (wrapper)



27

## Audio-Visual Container

- MP4
- MOV
- AVI

- MXF
- Matroska (.mkv)

- Flash

28

## Audio Codec

- WAVE
- BWF
- FLAC
- AAC
- MP3

29

## Video Codec

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

30

## Audio Data

- pcm\_s16le
- pcm\_s24le
- pcm\_s32le

31

## Video Data

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

32

## «Single-Image Codec»

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

33

## «Single-Image Container»

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

34

## What is inside my DPX?

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

35

# File Formats

36

## 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

37

## Different Purposes

archive master format:

→ for preservation

mezzanine format:

→ for professional use in post-production

dissemination formats:

→ for widely spreading and easy access

38

Elena Rossi-Snook:

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

39

## 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

40

## 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

41

## 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

42

## Archive Master and Mezzanine

### film

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

### video

- Matroska, FFV1, HD, Y'C<sub>B</sub>C<sub>R</sub>, 4:2:2, 10 bit

### audio

- Matroska, FLAC, 96 kHz, 24 bit

43

## Access

### WebM (a subset of Matroska)

#### Video

- «H.265», HD, yuv420p

#### Sound

- «FLAC», 48 kHz, 16 bit

44

## 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](https://retokromer.ch/publications/JFP_96.html)

45

## Pros & Cons

46

### container:

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

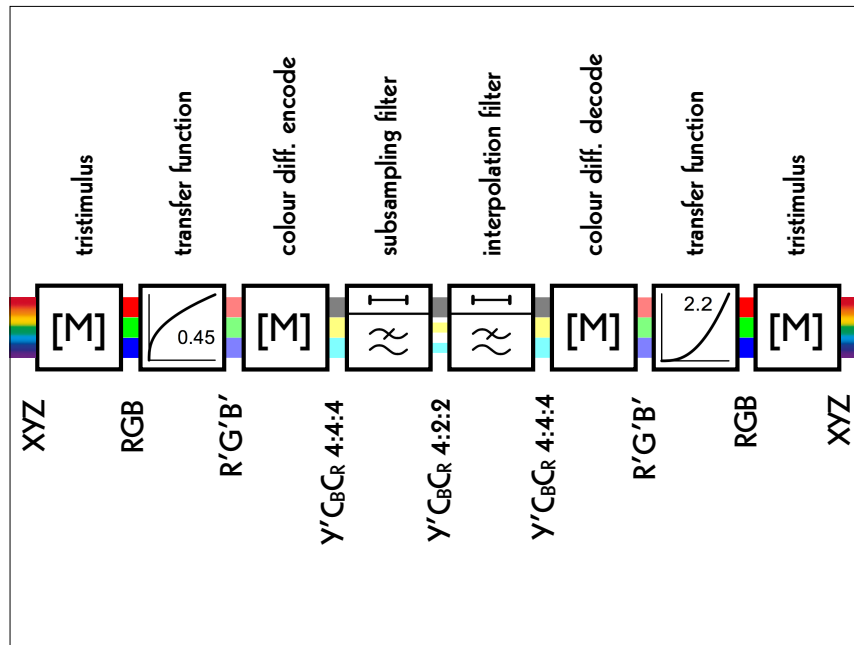
### codec:

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

47

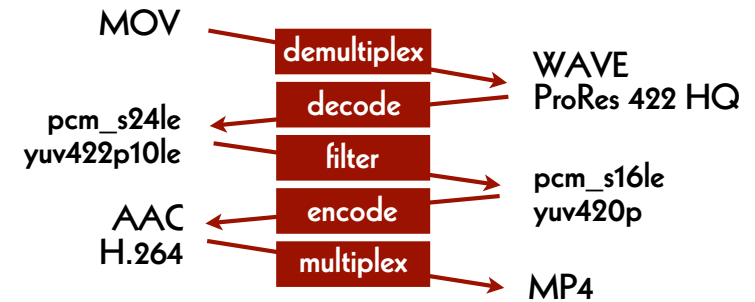
## Transformations

48



49

## Audio-Visual Exemple



50

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51

## AV Preservation by reto.ch

chemin du Suchet 5  
1024 Écublens  
Switzerland

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



52