Formats de fichiers audiovisuels

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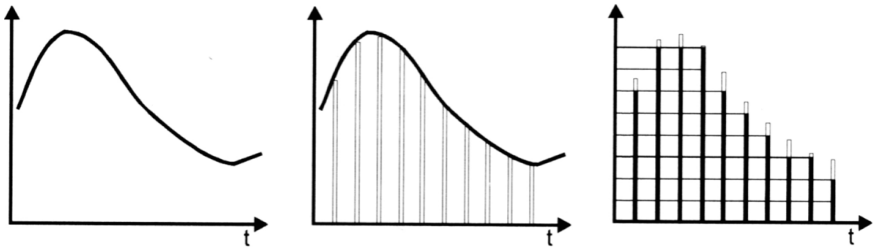
Atelier Memoriav
Logiciels ouverts dans l'archive
Berne, 11 janvier 2024

Table des matières

Audio numérique

Audio numérique

- échantillonnage
- quantification
- compression



numérisation = échantillonnage + quantification

Échantillonnage

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

Quantification

- 16 bit (2^{16} = 65 536)
- 24 bit (2^{24} = 16 777 216)
- 32 bit (2^{32} = 4 294 967 296)

Vidéo numérique

Vidéo numérique

- définition
- profondeur de couleurs
- linéaire, exponentielle, logarithmique
- espace colorimétrique
- compression et sous-échantillonnage
- illuminant

Définition

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

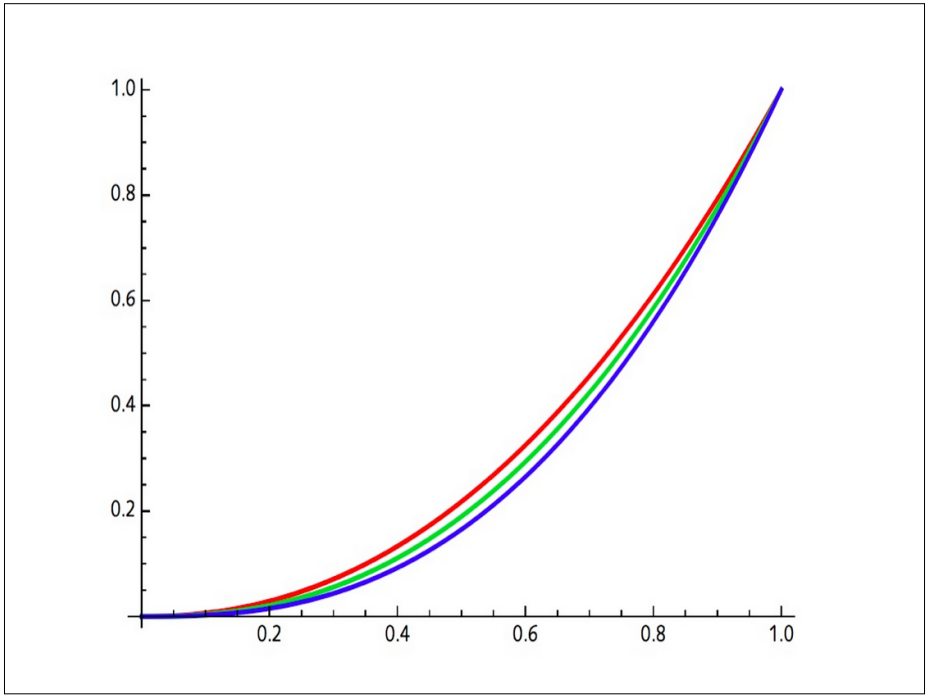
Profondeur de couleurs

- 8 bit ($2^8 = 256$)
- 10 bit ($2^{10} = 1\,024$)
- 12 bit ($2^{12} = 4\,096$)
- 16 bit ($2^{16} = 65\,536$)
- 24 bit ($2^{24} = 16\,777\,216$)

Linéaire, exponentielle, logarithmique

«gris moyen»

- fonction linéaire: environ 18%
- fonction exponentielle: 50%
- fonction logarithmique: 50%

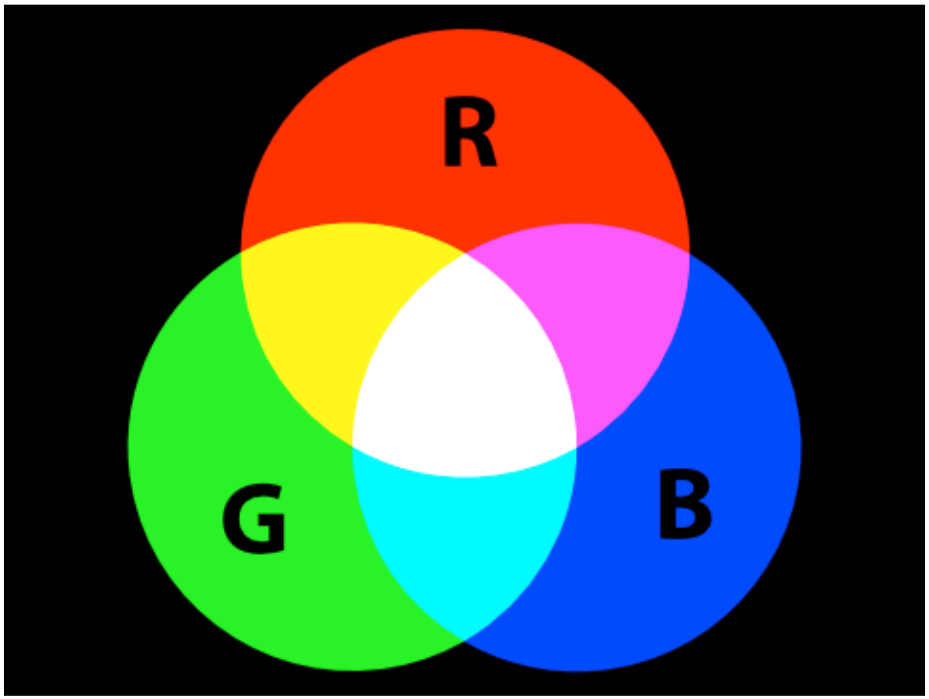


13

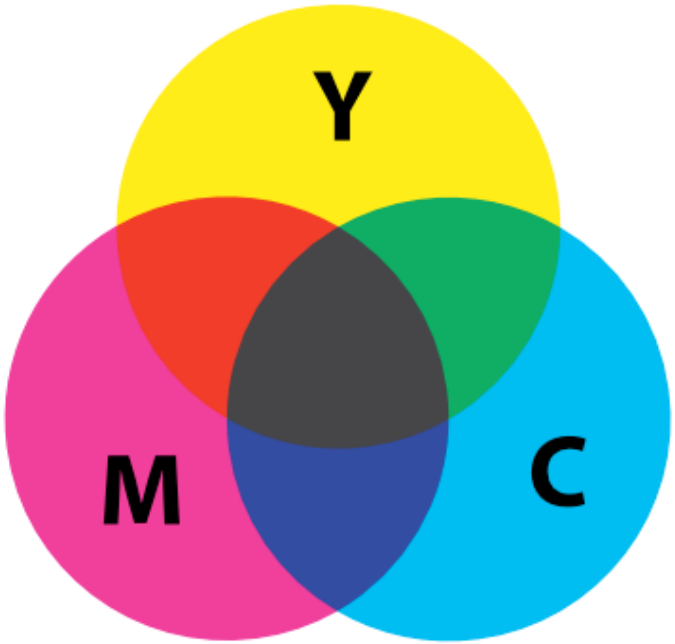
Espace colorimétrique

- XYZ, L*a*b*
- RGB / R'G'B' / CMY / C'M'Y'
- Y'IQ / Y'UV / $Y'D_BD_R$
- $Y'C_BC_R$ / $Y'C_OC_G$
- $Y'P_BP_R$

14



15



16

$$\begin{pmatrix} R' \\ G' \\ B' \end{pmatrix} = \begin{pmatrix} 1 & 0 & 1.396523 \\ 1 & -0.342793 & -0.711348 \\ 1 & 1.765078 & 0 \end{pmatrix} \begin{pmatrix} Y' \\ C_B \\ C_R \end{pmatrix}$$

$$\begin{pmatrix} Y' \\ C_B \\ C_R \end{pmatrix} = \begin{pmatrix} 0.299 & 0.587 & 0.114 \\ -0.168074 & -0.329965 & 0.498039 \\ 0.498039 & -0.417947 & -0.080992 \end{pmatrix} \begin{pmatrix} R' \\ G' \\ B' \end{pmatrix}$$

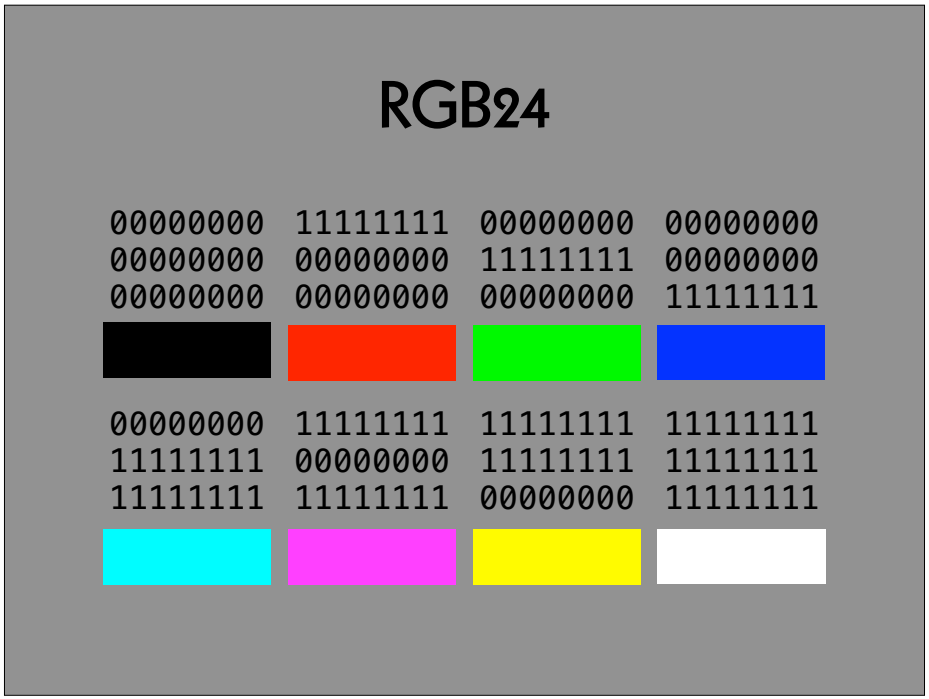
17

$$\begin{pmatrix} R' \\ G' \\ B' \end{pmatrix} = \begin{pmatrix} 1 & 1 & -1 \\ 1 & 0 & 1 \\ 1 & -1 & -1 \end{pmatrix} \begin{pmatrix} Y' \\ C_O \\ C_G \end{pmatrix}$$

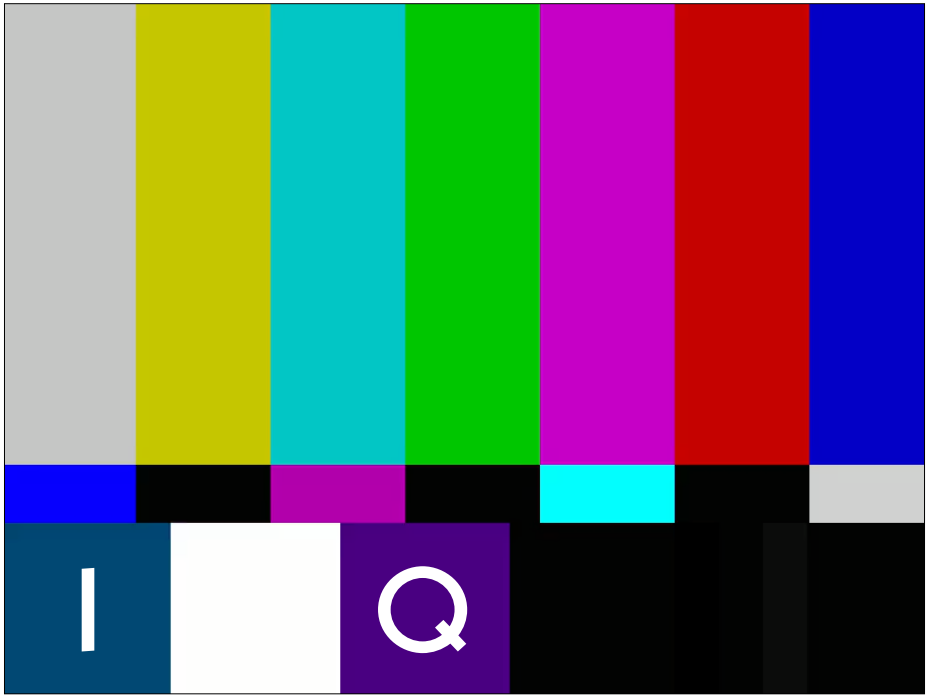
$$\begin{pmatrix} Y' \\ C_O \\ C_G \end{pmatrix} = \begin{pmatrix} \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{2} & 0 & -\frac{1}{2} \\ -\frac{1}{4} & \frac{1}{2} & -\frac{1}{4} \end{pmatrix} \begin{pmatrix} R' \\ G' \\ B' \end{pmatrix}$$

18

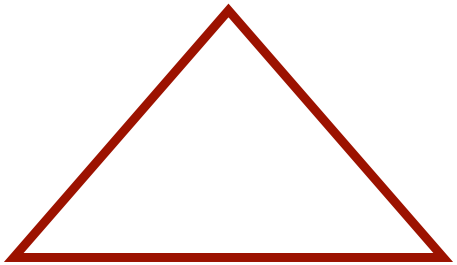
19



20



qualité de l'image



temps d'encodage taille du fichier

Compression

- non compressé
- compressé sans perte
- compressé avec perte
- sous-échantillonnage
- compressé à la création

Non compressé

+ données plus faciles à traiter
+ logiciels plus rapides à exécuter
− fichiers plus lourds
− fichiers plus lents à écrire, lire et transmettre

Exemples: TIFF, DPX, DNG, OpenEXR

Compressé sans perte

+ fichiers plus légers
+ plus rapides à lire, écrire, transmettre
− données plus complexes à traiter
− logiciels plus longs à exécuter

Exemples: JPEG 2000, FFV1

Compressé avec perte

- optimisé pour l'acquisition et/ou pour la postproduction
- optimisé pour la diffusion

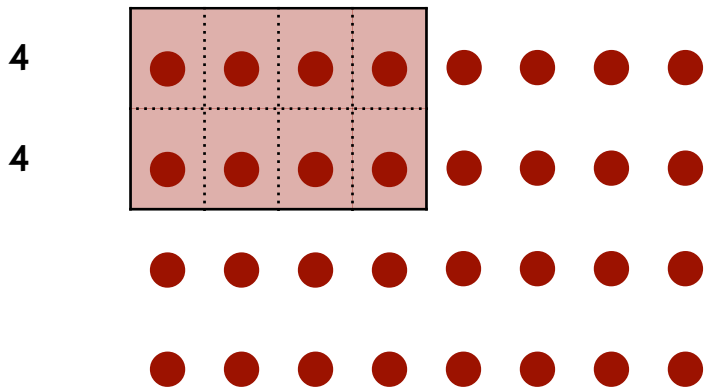
Exemples (mezzanine): ProRes 422, ProRes 4444, DNxHD, DNxHR

Exemples (diffusion): H.264 (AVC), H.265 (HEVC), H.266 (VVC); AV1

Sous-échantillonnage

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

4:4:4



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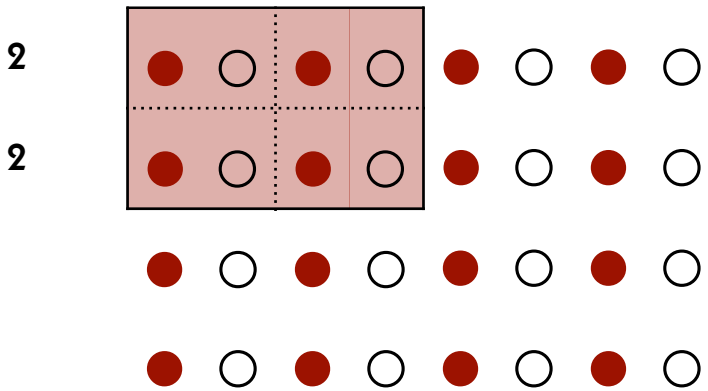
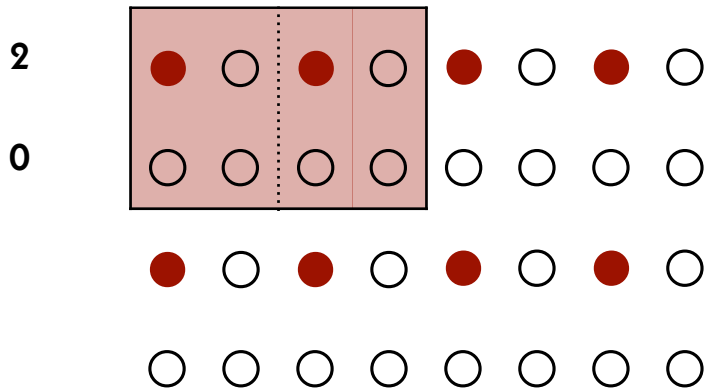
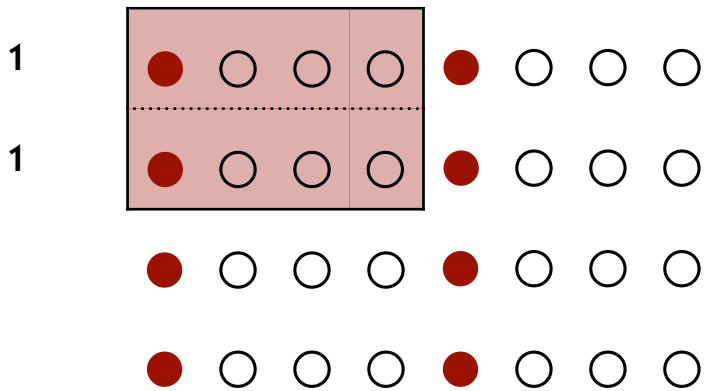


4:2:0



4:1:1



Compressé à la création

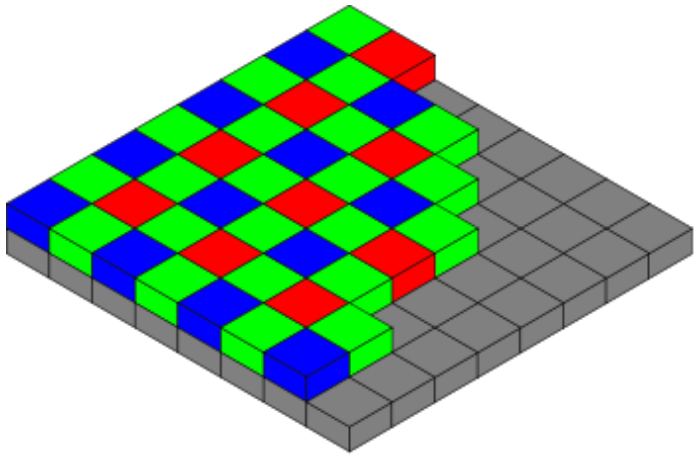
- optimisé tant pour l'acquisition que pour la postproduction

Exemples: CineForm RAW, ProRes RAW, Blackmagic RAW

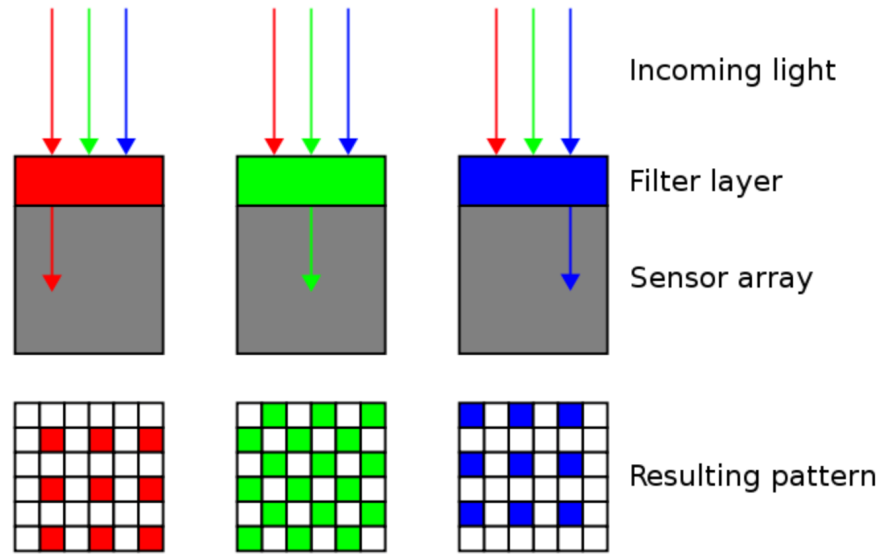
Vérités qui dérangent

- les capteurs sont daltoniens
- les capteurs de type Bayer ne produisent pas une image RGB complète, mais seulement un tiers de l'information

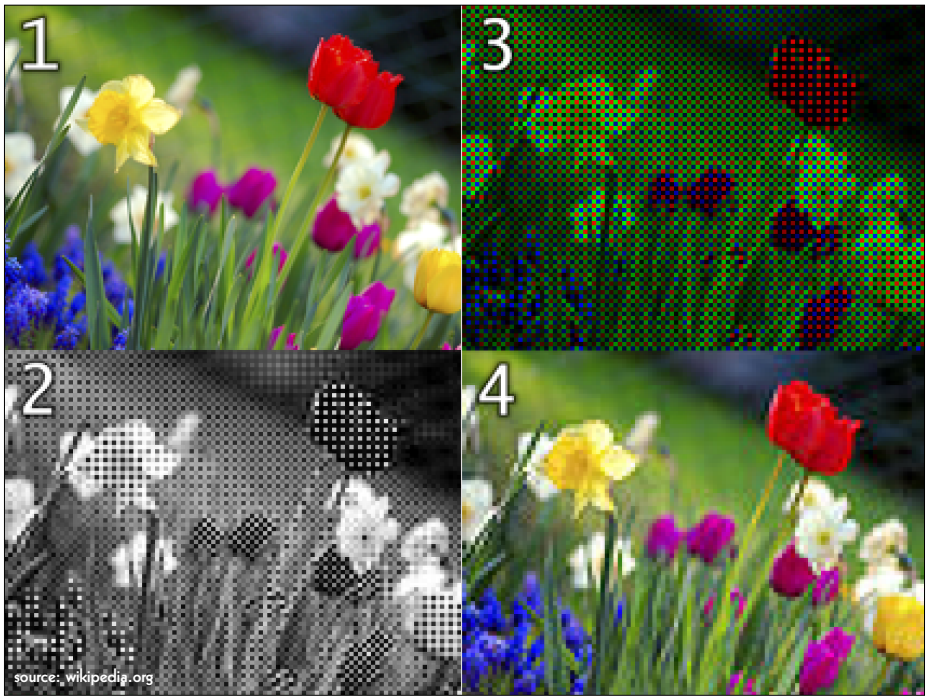
Bayer



source: wikipedia.org



source: wikipedia.org



source: wikipedia.org

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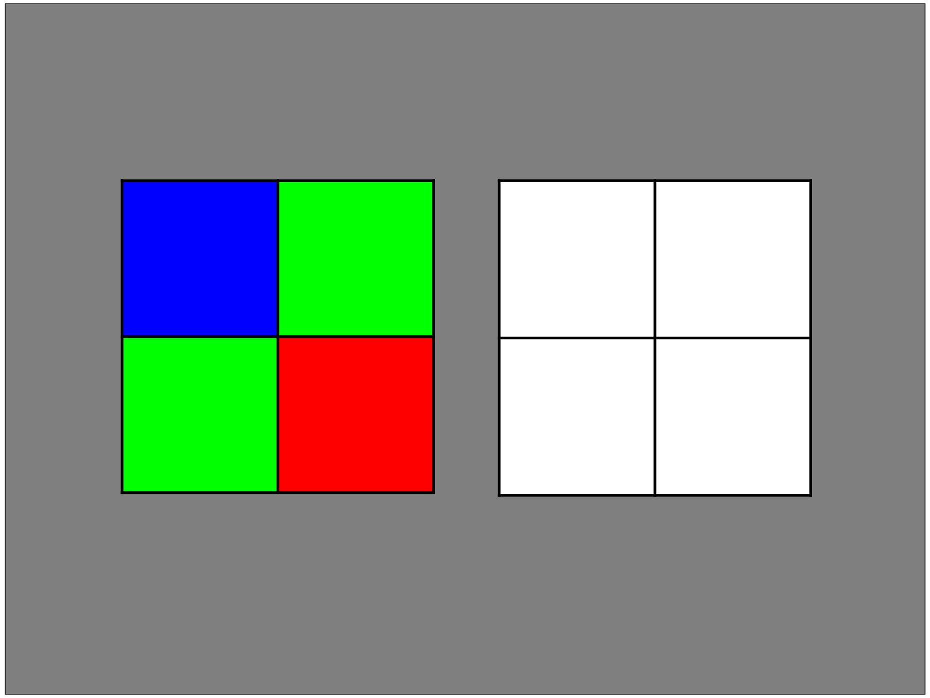
37



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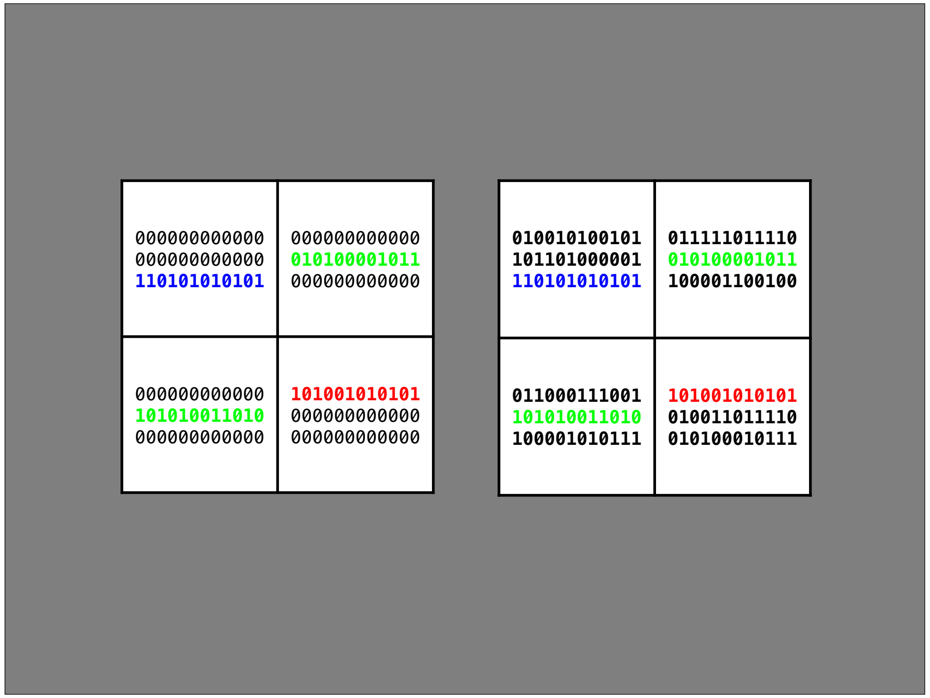
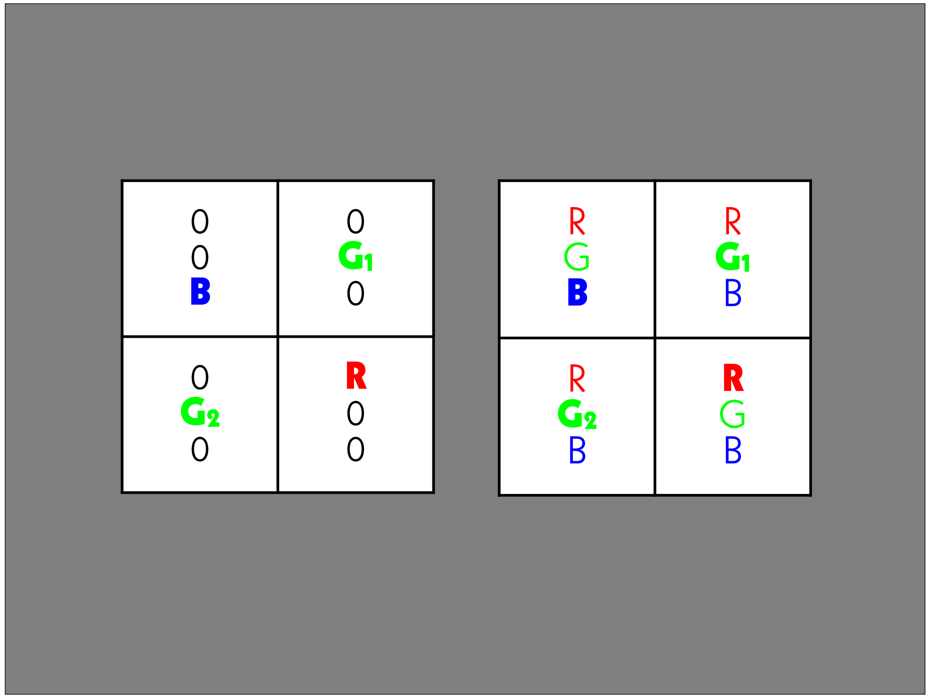


39



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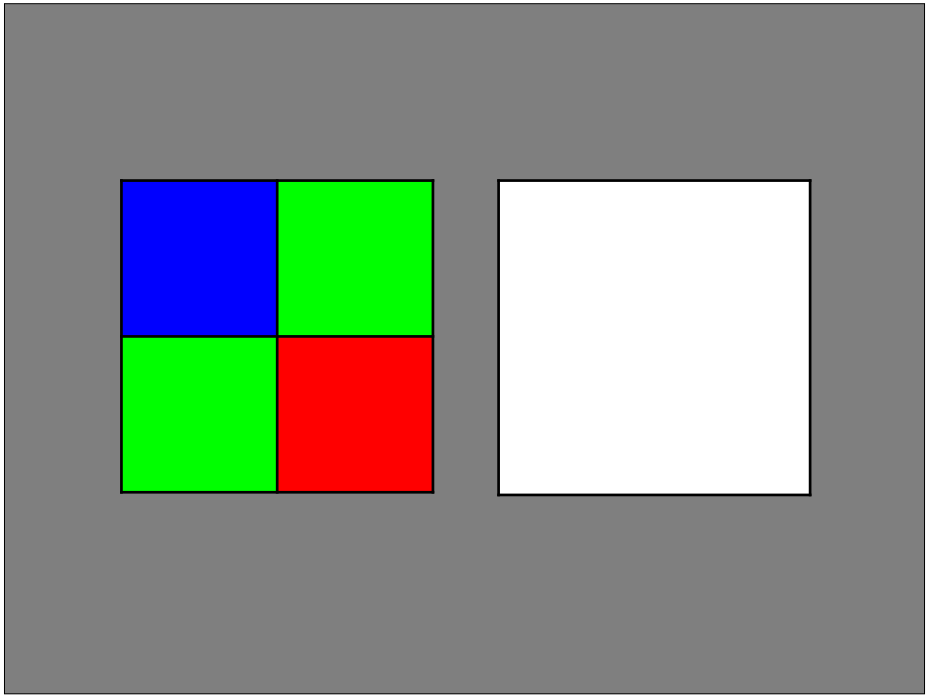
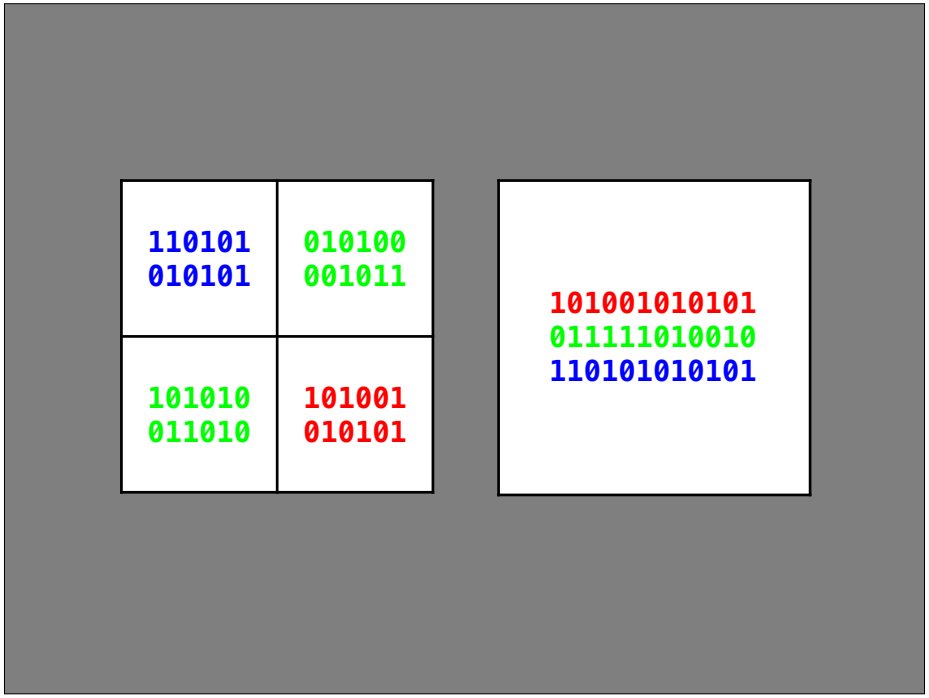
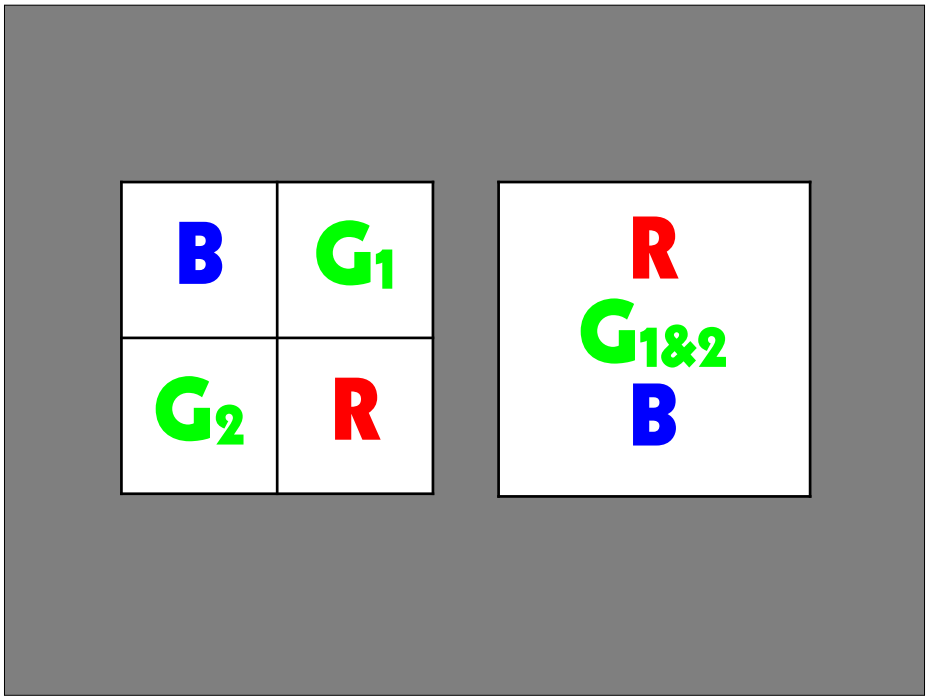


41



42



43

Façons d'utiliser les données Bayer

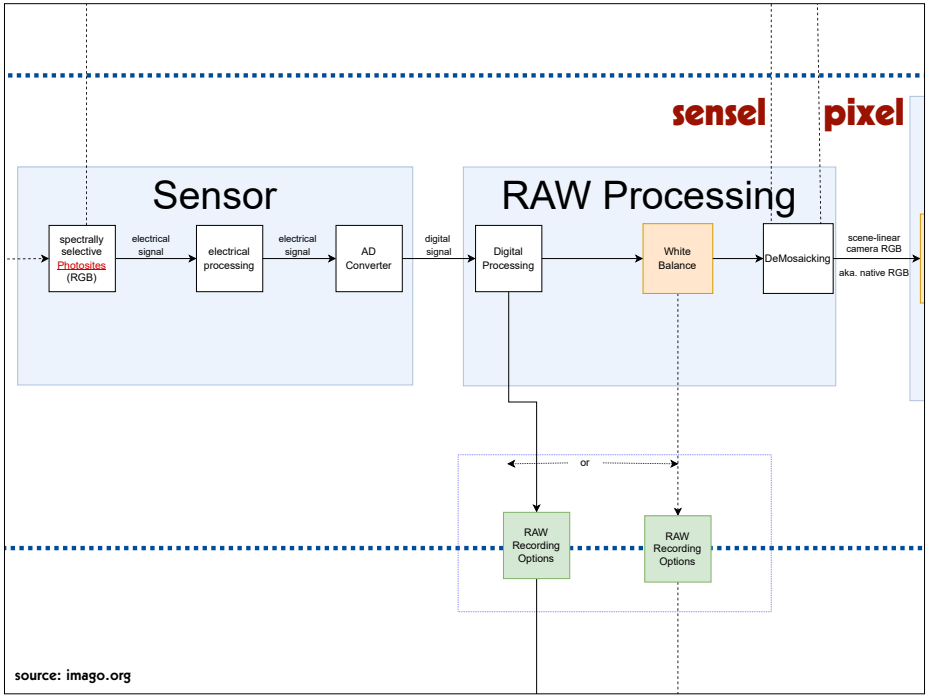
gonflage numérique en RGB

- les données générées sont triplées
- le fichier a la définition complète du capteur
- seule la moitié des données est réelle

réduction numérique en RGB

- les trois quarts des données générées sont stockées
- le fichier a la moitié de la définition du capteur
- toutes les données sont réelles

44

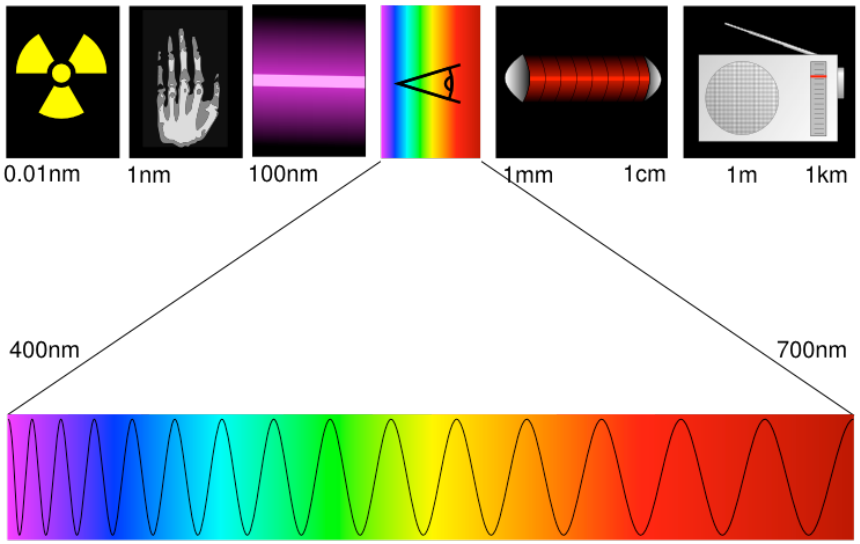


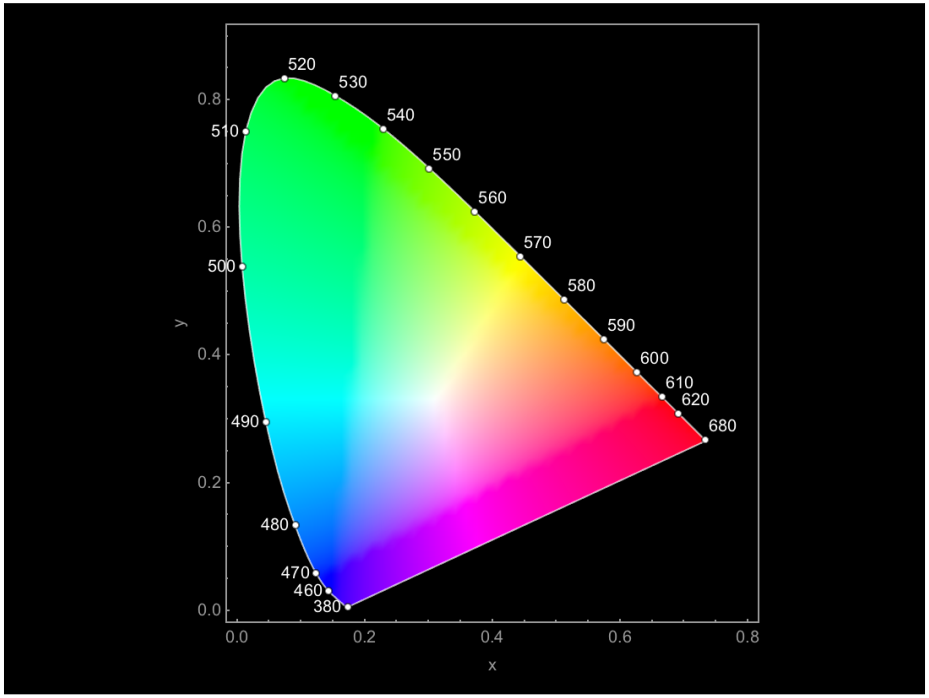
Façons de stocker les données Bayer

- pixel values generated by one de-mosaicking algorithm (digital blow-up)
- pixel values generated by mixing two green sensel values into one (digital reduction)
- raw sensel values

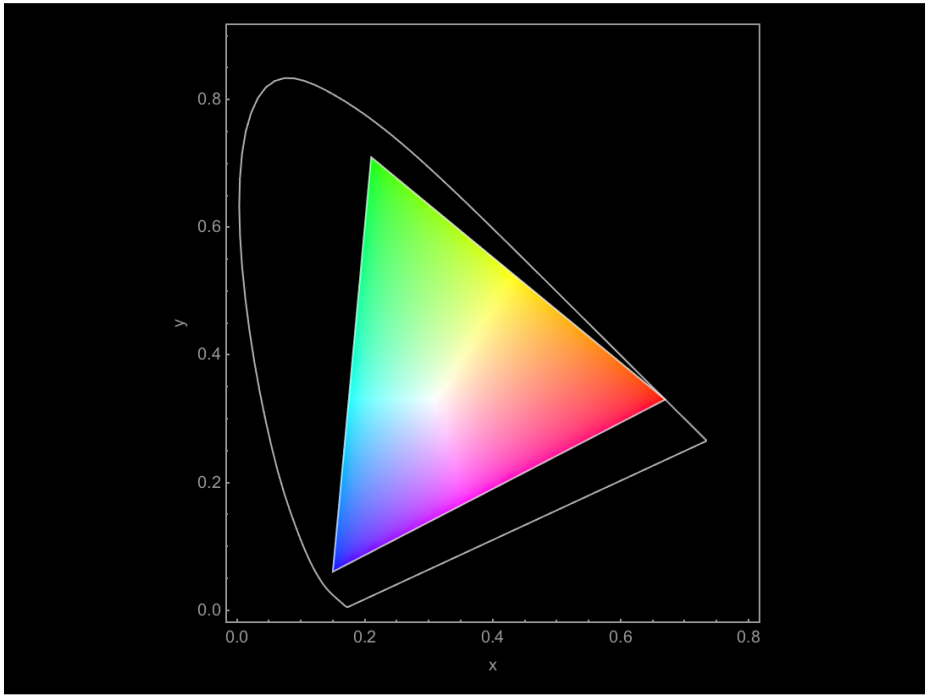
Illuminant

- D50
- D55
- D65
- D75





49



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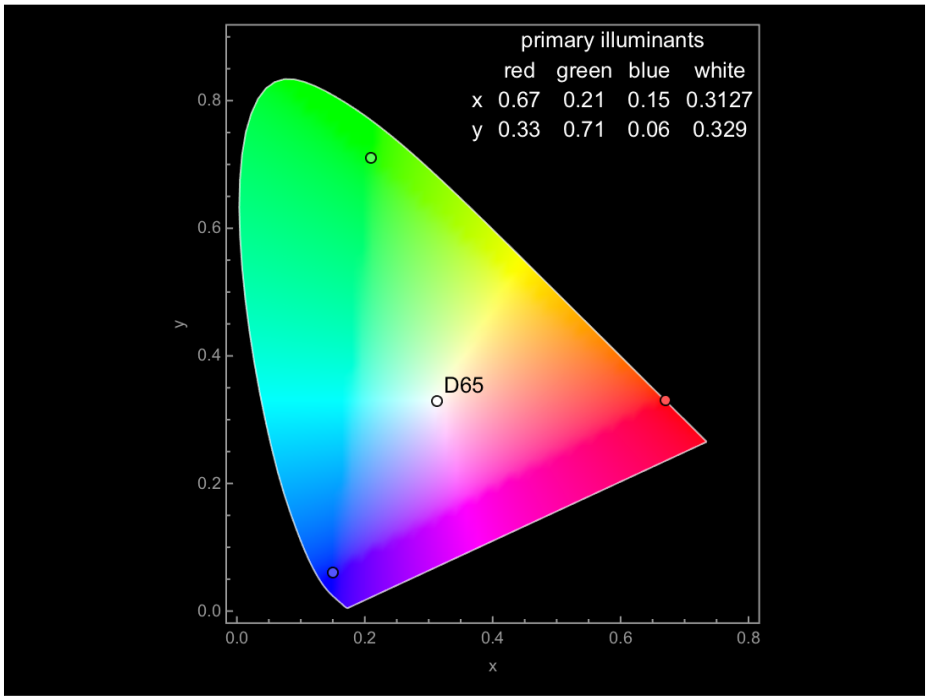
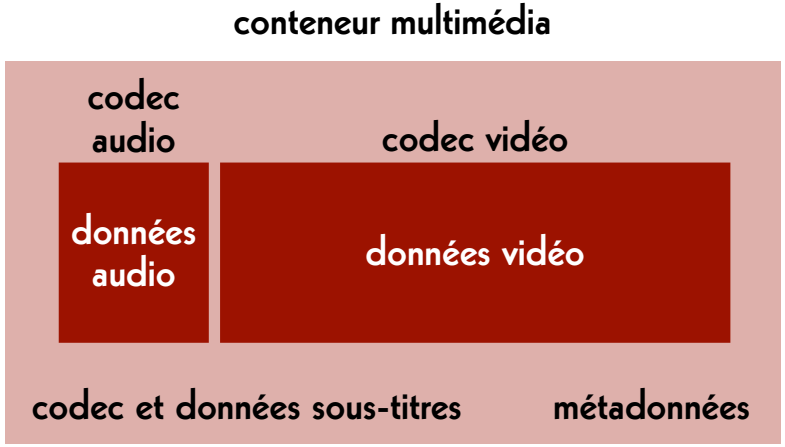


51

Structure des fichiers

52

Structure des fichiers



Conteneur multimédia

- MP4
- QuickTime (.mov)
- AVI
- MXF
- Matroska (.mkv)
- Flash

Images individuelles

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

Codec audio

- WAVE
- BWF
- FLAC
- AAC
- MP3

Codec vidéo (master)

images

- TIFF
- DPX
- JPEG 2000
- OpenEXR
- DNG

vidéo

- 8 bit raw
- 10 bit raw
- HuffYUV
- FFV1

Codec vidéo (mezzanine)

- ProRes 422, ProRes 4444, ProRes RAW
- DNxHD, DNxHR
- CineForm RAW
- Blackmagic RAW

Codec vidéo (accès)

- H.264 (AVC)
- H.265 (HEVC)
- H.266 (VVC)

- AV1

RAW data are cooked.

Données audio

- pcm_s16le
- pcm_s24le
- pcm_s32le

Données vidéo

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

Que contient mon DPX?

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

Formats de fichiers

Principes

- **Une archive doit être capable de traiter les formats de fichiers qu'elle possède.**

- open source
- simple à utiliser et bien documenté
- largement utilisé par la communauté

Différents formats pour différentes utilisations

master d'archivage
→ pour la préservation et l'archivage

formats mezzanine
→ pour le montage et la postproduction

formats de distribution
→ pour la diffusion et l'accès

Elena Rossi-Snook:

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

Master d'archivage (actuel)

images individuelles («film»)
- dossier, TIFF, 2K ou 4K, RGB, 16 bit
- MXF, DPX, 2K ou 4K, R'G'B', 10 bit

flux d'images («vidéo»)
- 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

Formats mezzanine (actuel)

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

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

Formats de distribution (actuel)

MP4

image
- H.264, SD, $Y'C_BC_R$ 4:2:0, 8 bit, lossy
- H.264, «HD», $Y'C_BC_R$ 4:2:0, 8 bit, lossy

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

Master d'archive et mezzanine

images individuelles («film»)
- Matroska, FFV1, 4K ou 2K, RGB, 16 bit
- Matroska, FFV1, 4K ou 2K, R'G'B', 12 bit

flux d'images («vidéo»)
- Matroska, FFV1, «HD», $Y'C_BC_R$ 4:4:4, 10 bit
- Matroska, FFV1, «HD», $Y'C_BC_R$ 4:4:4, 12 bit

son
- Matroska, FLAC, 192 kHz, 24 bit

Formats de distribution

MP4

image
- H.265, «HD», $Y'C_BC_R$ 4:2:0, 8 bit, lossy
- H.266, «HD», $Y'C_BC_R$ 4:2:0, 8 bit, lossy
- AV1, «HD», $Y'C_BC_R$ 4:2:0, 8 bit, lossy

son
- AAC, 48 kHz, 16 bit
- AAC, 96 kHz, 16 bit

Bibliographie

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

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

Avantages et inconvénients

conteneur:

- dossier
- TAR
- ZIP
- MXF
- Matroska

codec:

- TIFF
- DPX
- JPEG 2000
- FFV1
- OpenEXR
- CineForm RAW
- ProRes RAW
- Blackmagic RAW

	avantages	inconvénients
TIFF DPX OpenEXR	traitement plus simple	fichiers plus lourds
JPEG 2000 FFV1	fichiers plus légers	traitement plus complexe

Un pont entre les deux mondes

RAWcooked (CLI)

➔ mediaarea.net/RAWcooked

RAWcooked

- encoding into Matroska (.mkv) using FFV1 video codec and FLAC audio codec
- all metadata preserved
- decoding with bit-by-bit reversibility
- possibility to embed sidecar files (e.g. MD5, LUT, XML)
- compatibility with media players

Conteneur MXF (.mxf)

codec vidéo

- DPX
- JPEG 2000
- DNxHD, DNxHR
- ProRes 422, ProRes 4444

SMPTE REGISTERED DISCLOSURE DOCUMENT

MXF Archive and Preservation Format Registered Disclosure Document

The attached document is a Registered Disclosure Document prepared by the sponsor identified below. It has been examined by the appropriate SMPTE Technology Committee and is believed to contain adequate information to satisfy the objectives defined in the Scope, and to be technically consistent.

This document is NOT a Standard, Recommended Practice or Engineering Guideline, and does NOT imply a finding or representation of the Society.

Every attempt has been made to ensure that the information contained in this document is accurate. Errors in this document should be reported to the proponent identified below, with a copy to eng@smpte.org.

All other inquiries in respect of this document, including inquiries as to intellectual property requirements that may be attached to use of the disclosed technology, should be addressed to the proponent identified below.

Proponent Contact Information:
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101 Independence Ave, S.E.
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Email: kmur@loc.gov

MXF / DPX

MXF
- ➔ SMPTE RDD 48:2018

DPX
- ➔ SMPTE ST 268M:2015

MXF / JPEG 2000

MXF
- ➔ SMPTE RDD 48:2018

JPEG 2000
- ➔ ISO/IEC 15444-1:2019
- ➔ etc.

MXF / DNx

MXF
- ➔ SMPTE RDD 48:2018

DNxHD, DNxHR
- ➔ non publié

MXF / ProRes

MXF
- ➔ SMPTE RDD 48:2018

ProRes 422, ProRes 4444
- ➔ SMPTE RDD 36:2015

SMPTE RDD 36:2015

SMPTE REGISTERED DISCLOSURE DOCUMENT

Apple ProRes Bitstream Syntax and Decoding Process

Page 1 of 39 pages

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Proponent contact information:

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1 Infinite Loop, MS: 77-2YAK
Cupertino, CA 95014
USA

Email: ProRes@apple.com

85

Conteneur Matroska (.mkv)

codec vidéo

- FFV1
- ProRes 422, ProRes 4444

86

Matroska / FFV1

Matroska (.mkv)
➔ IETF Internet Draft

ProRes 422, ProRes 4444
➔ SMPTE RDD 36:2015

87

Stream: Internet Engineering Task Force (IETF)
RFC: 9043
Category: Informational
Published: August 2021
ISSN: 2070-1721
Authors: M. Niedermayer D. Rice J. Martinez

RFC 9043
FFV1 Video Coding Format Versions 0, 1, and 3

Abstract

This document defines FFV1, a lossless, intra-frame video encoding format. FFV1 is designed to efficiently compress video data in a variety of pixel formats. Compared to uncompressed video, FFV1 offers storage compression, frame fixity, and self-description, which makes FFV1 useful as a preservation or intermediate video format.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for informational purposes.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Not all documents approved by the IESG are candidates for any level of Internet Standard; see Section 2 of RFC 7841.

Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at https://www.rfc-editor.org/info/rfc9043.

88

Matroska / ProRes

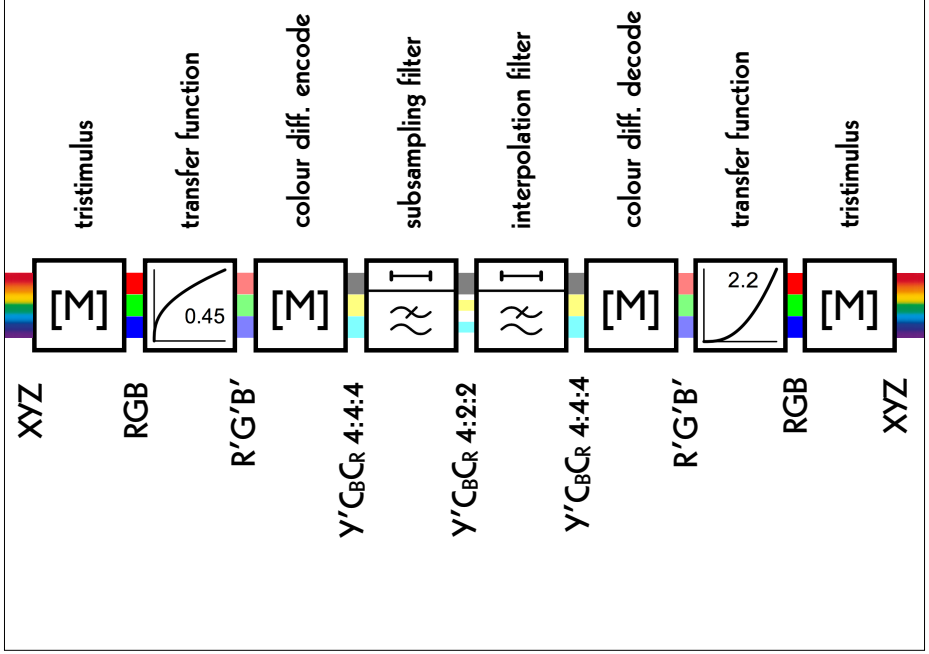
Matroska (.mkv)

➔ IETF Internet Draft

ProRes 422, ProRes 4444

➔ SMPTE RDD 36:2015

Transformations



Transformations de fichiers

démultiplexage

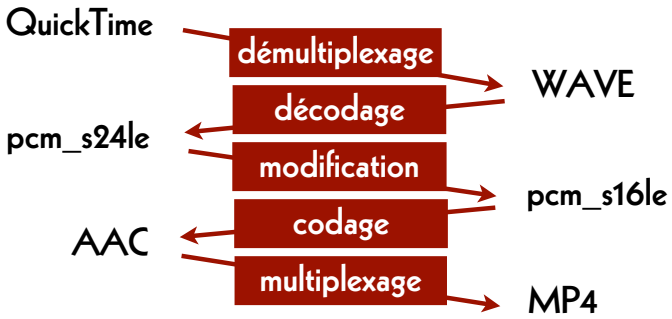
décodage

modification

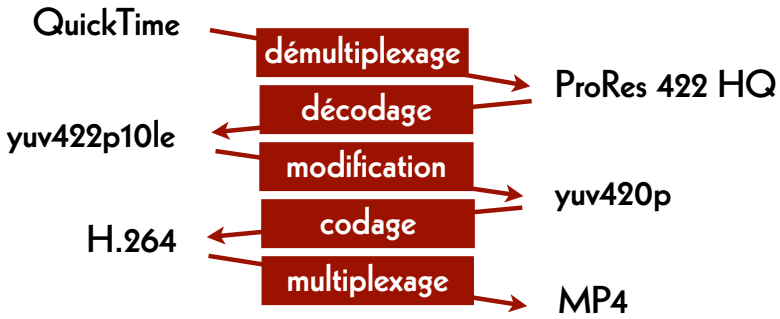
codage

multiplexage

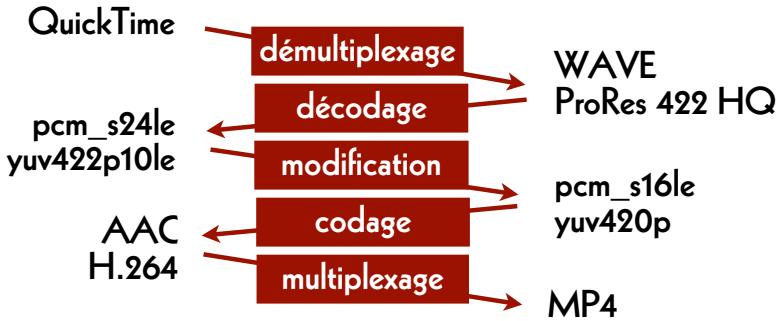
Exemple: audio



Exemple: vidéo



Exemple: audiovisuel



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