An Introduction to FFmpeg

Reto Kromer • AV Preservation by reto.ch

Open-Source Tools and Resources for Audio-Visual Archives
Elías Querejeta Zine Eskola
Donostia (San Sebastián), Spain
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Interacting with the computer

- command-line interface (CLI)
- graphical user interface (GUI)

Software

The FFmpeg Family

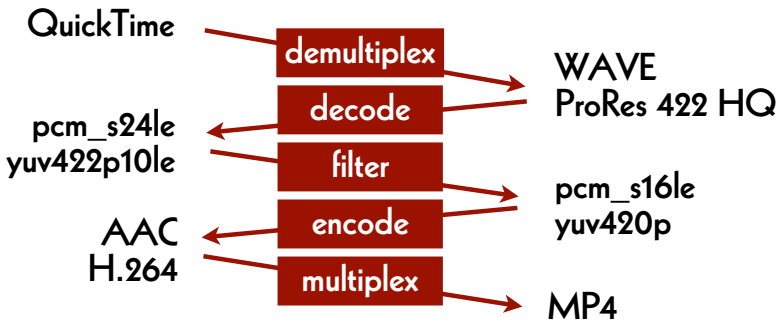
Tools

- ffmpeg
- ffprobe
- ffplay

Libraries

- libavutil
- libavcodec
- libavformat
- libavdevice
- libavfilter
- libswscale
- libswresample
- libpostproc

Audio-Visual Exemple



Data Transformations

File Transformations

ffmpeg (CLI)

➔ ffmpeg.org

FFmpeg Cookbook for Archivists

➔ avpres.net/FFmpeg/

ffmprovisr

➔ amiaopensource.github.io/ffmprovisr/

Metadata Extraction

MediaInfo (GUI, CLI)

➔ mediaarea.net/MediaInfo

ffprobe (CLI)

➔ ffmpeg.org

Media Player

VLC (GUI)

➔ www.videolan.org/vlc/

mpv (CLI)

➔ mpv.io

ffplay (CLI)

➔ ffmpeg.org

A GUI for FFmpeg

FFCommand Engine (GUI)

➔ github.com/ColorlabMD/FFCommand_Engine

version 0.6 for macOS via Homebrew:

```
brew tap avpres/formulae
brew install --HEAD ffcommand-engine
```


	avantages	disavantages
TIFF **DPX** **OpenEXR**	data easier to process	bigger files
JPEG 2000 **FFV1**	smaller files	data complexer to process

Single Images and Streams

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, for example MD5, LUT, XML, PDF
- compatibility with media players

Basics

Set the Working Space

Linux/Mac/Windows Terminal or WSL:

```
cd ~/Desktop
```

Windows locally:

```
cd Desktop
```

Windows on OneDrive Cloud:

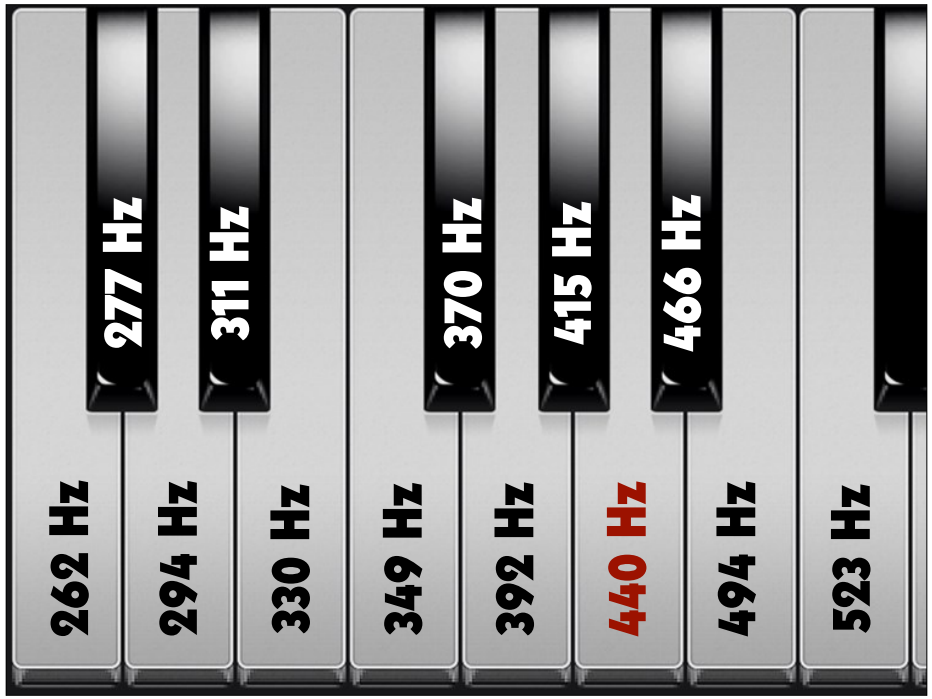
```
cd OneDrive
```

Generate an Image File

```
ffmpeg
  -lavfi mandelbrot
  -t 10
  -c:v rawvideo
  -pix_fmt uyvy422
  mandelbrot.avi
```


Play the Image File

```
ffplay
  mandelbrot.avi
```

Generate a Sound File

```
ffmpeg
  -lavfi sine=frequency=440
  -t 10
  la.wav
```

Play the Sound File

```
ffplay
  la.wav
```


Merge Image and Sound

```
ffmpeg
  -i mandelbrot.avi
  -i la.wav
  -c:v copy
  -c:a copy
  mandela.avi
```


Play the AV File

```
ffplay
  mandela.avi
```


Extract the Metadata

```
ffprobe
  mandela.avi
```

Container

```
ffprobe
  -show_format
  mandela.avi
```


Codec

```
ffprobe
  -show_streams
  mandela.avi
```


Container and Codec

```
ffprobe
  -show_format
  -show_streams
  mandela.avi
```


Format the Output

```
ffprobe
  -show_format
  -show_streams
  -print_format json
  mandela.avi
```

Save the Metadata

```
ffprobe
  -show_format
  -show_streams
  -print_format json
  mandela.avi
  > mandela.txt
```


Find Help

```
ffmpeg -h
ffmpeg -codecs
ffmpeg -decoders
ffmpeg -h decoder=aac
ffmpeg -encoders
ffmpeg -h encoder=libx264
ffmpeg -filters
ffmpeg -pix_fmts
```


Modify the Container

```
ffmpeg
  -i mandelbrot.avi
  -c copy
  mandelbrot.mov
```


Generate Checksums (1)

```
ffmpeg
  -i mandelbrot.avi
  -f framemd5
  mandelbrot_avi_framemd5.txt
```

Generate Checksums (2)

```
ffmpeg
  -i mandelbrot.mov
  -f framemd5
  mandelbrot_mov_framemd5.txt
```


Compare Checksum Files

Linux/Mac/Windows Terminal or WSL:

```
diff -s
  mandelbrot_avi_framemd5.txt
  mandelbrot_mov_framemd5.txt
```

Windows:

```
fc
  mandelbrot_avi_framemd5.txt
  mandelbrot_mov_framemd5.txt
```


Dufaycolor

Play Single Images

```
ffplay
  -loop 0
  DUFAY_TIFF/Dufay_%06d.tif
```

Different Purposes

archive master format:
➔ for preservation and archiving

mezzanine format:
➔ for professional use in post-production

dissemination formats:
➔ for widely spreading and easy access

File Transformations

- from the master file to a mezzanine file and from the mezzanine file to an access file
- from the master file to an access file

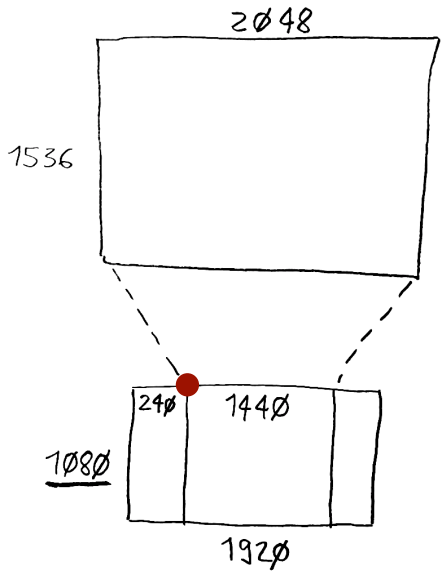
➔ Compare the quality of the access files.

➔ Compare the quality of the mezzanine files (Apple ProRes and AVID).

2K
4:3

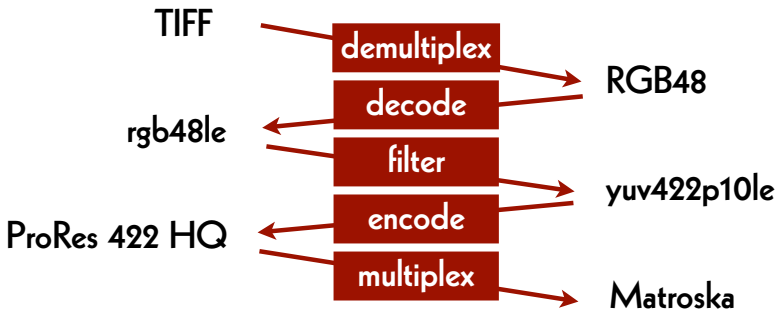
↓

HD
16:9



ProRes

From TIFF to ProRes



ProRes 422 and ProRes 4444

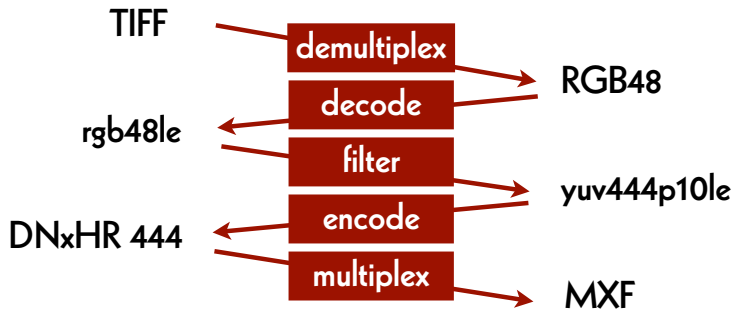
- QuickTime (.mov)
- Matroska (.mkv)
- MXF = Material eXchange Format (.mxl)

Master -> Mezzanine (1)

```
ffmpeg
  -f image2 -framerate 24
  -i DUFAY_TIFF/Dufay_%06d.tif
  -filter:v
    "scale=1440:1080:flags=lanczos,
     pad=1920:1080:240:0"
  -c:v prores_ks -profile:v 3
  Dufay_ProRes.mkv
```


AVID

From TIFF to DNxHR



Find Parameters

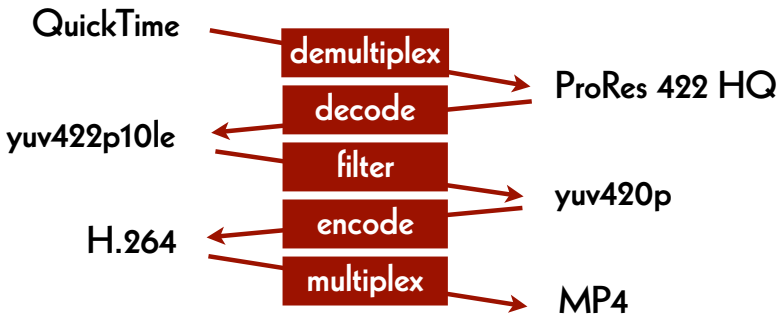
```
ffmpeg -h encoder=dnxhd

-profile:v dnxhr_lb -pix_fmt yuv422p
-profile:v dnxhr_sq -pix_fmt yuv422p
-profile:v dnxhr_hq -pix_fmt yuv422p
-profile:v dnxhr_hqx -pix_fmt yuv422p10le
-profile:v dnxhr_444 -pix_fmt yuv444p10le
-profile:v dnxhr_444 -pix_fmt gbrp10le
```


Master -> Mezzanine (2)

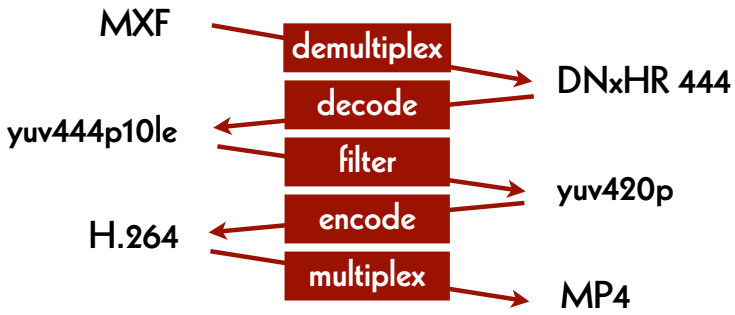
```
ffmpeg
  -f image2 -framerate 24
  -i DUFAY_TIFF/Dufay_%06d.tif
  -filter:v
    "scale=1440:1080:flags=lanczos,
     pad=1920:1080:240:0"
  -c:v dnxhd -profile:v dnxhr_444
  -pix_fmt yuv444p10le
  Dufay_DNxHR.mxf
```


H.264

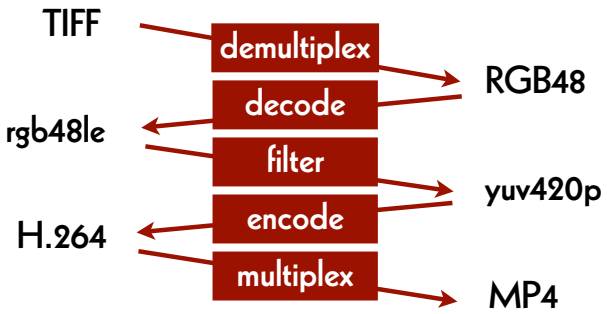
From ProRes to H.264

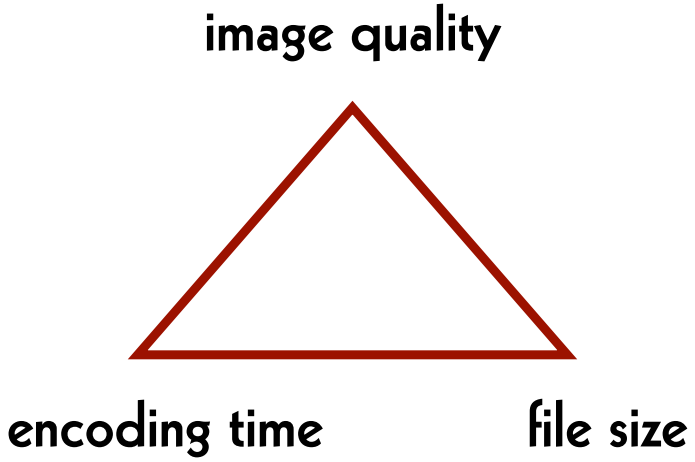


From ProRes to DNxHR



From TIFF to H.264





Mezzanine -> Access (1)

```
ffmpeg
  -i Dufay_ProRes.mkv
  -pix_fmt yuv420p
  -c:v libx264 -preset veryslow -crf 30
  Dufay_ProRes_H264.mp4
```


Mezzanine -> Access (2)

```
ffmpeg
  -i Dufay_DNxHR.mxf
  -pix_fmt yuv420p
  -c:v libx264 -preset veryslow -crf 30
  Dufay_DNxHR_H264.mp4
```


Master -> Access

```
ffmpeg
  -f image2 -framerate 24
  -i DUFAY_TIFF/Dufay_%06d.tif
  -filter:v
    "scale=1440:1080:flags=lanczos,
     pad=1920:1080:240:0"
  -pix_fmt yuv420p
  -c:v libx264 -preset veryslow -crf 30
  Dufay_master_H264.mp4
```


Quality control

- difference file ("delta" file)
- split screen

Split screen (1)

```
ffmpeg
  -i Dufay_master_H264.mp4
  -i Dufay_ProRes_H264.mp4
  -filter_complex
    "[0]crop=iw/2:ih:0:0[left];
     [1]crop=iw/2:ih:iw/2:0[right];
     [left][right]hstack"
  Dufay_split_ProRes.mp4
```


Split screen (2)

```
ffmpeg
  -i Dufay_master_H264.mp4
  -i Dufay_DNxHR_H264.mp4
  -filter_complex
    "[0]crop=iw/2:ih:0:0[left];
     [1]crop=iw/2:ih:iw/2:0[right];
     [left][right]hstack"
  Dufay_split_DNxHR.mp4
```


Split screen (3)

```
ffmpeg
  -i Dufay_ProRes_H264.mp4
  -i Dufay_DNxHR_H264.mp4
  -filter_complex
    "[0]crop=iw/2:ih:0:0[left];
     [1]crop=iw/2:ih:iw/2:0[right];
     [left][right]hstack"
  Dufay_split_mezzanine.mp4
```


Test Filter

```
ffplay
  -vf "negate"
  Dufay_1_H264.mp4
```

Difference file (1)

```
ffmpeg
  -i Dufay_master_H264.mp4
  -i Dufay_ProRes_H264.mp4
  -filter_complex
    "[1]format=yuva444p,
        lut=c3=128,
        negate[1_with_alpha];
     [0][1_with_alpha]overlay"
  Dufay_delta_ProRes.mp4
```


Difference file (2)

```
ffmpeg
  -i Dufay_master_H264.mp4
  -i Dufay_DNxHR_H264.mp4
  -filter_complex
    "[1]format=yuva444p,
        lut=c3=128,
        negate[1_with_alpha];
     [0][1_with_alpha]overlay"
  Dufay_delta_DNxHR.mp4
```


Difference file (3)

```
ffmpeg
  -i Dufay_ProRes_H264.mp4
  -i Dufay_DNxHR_H264.mp4
  -filter_complex
    "[1]format=yuva444p,
        lut=c3=128,
        negate[1_with_alpha];
     [0][1_with_alpha]overlay"
  Dufay_delta_mezzanine.mp4
```


AV Preservation by reto.ch

zone industrielle Le Trési 3
1028 Préverenges
Switzerland

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