A/V Data Compression Basics

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Compressed? Uncompressed?

Speaker notes

What does that mean? What is “uncompressed”? What is “data compression”?

It’s not only technical, but highly political… Including Fear, Uncertainty and Doubt (FUD).

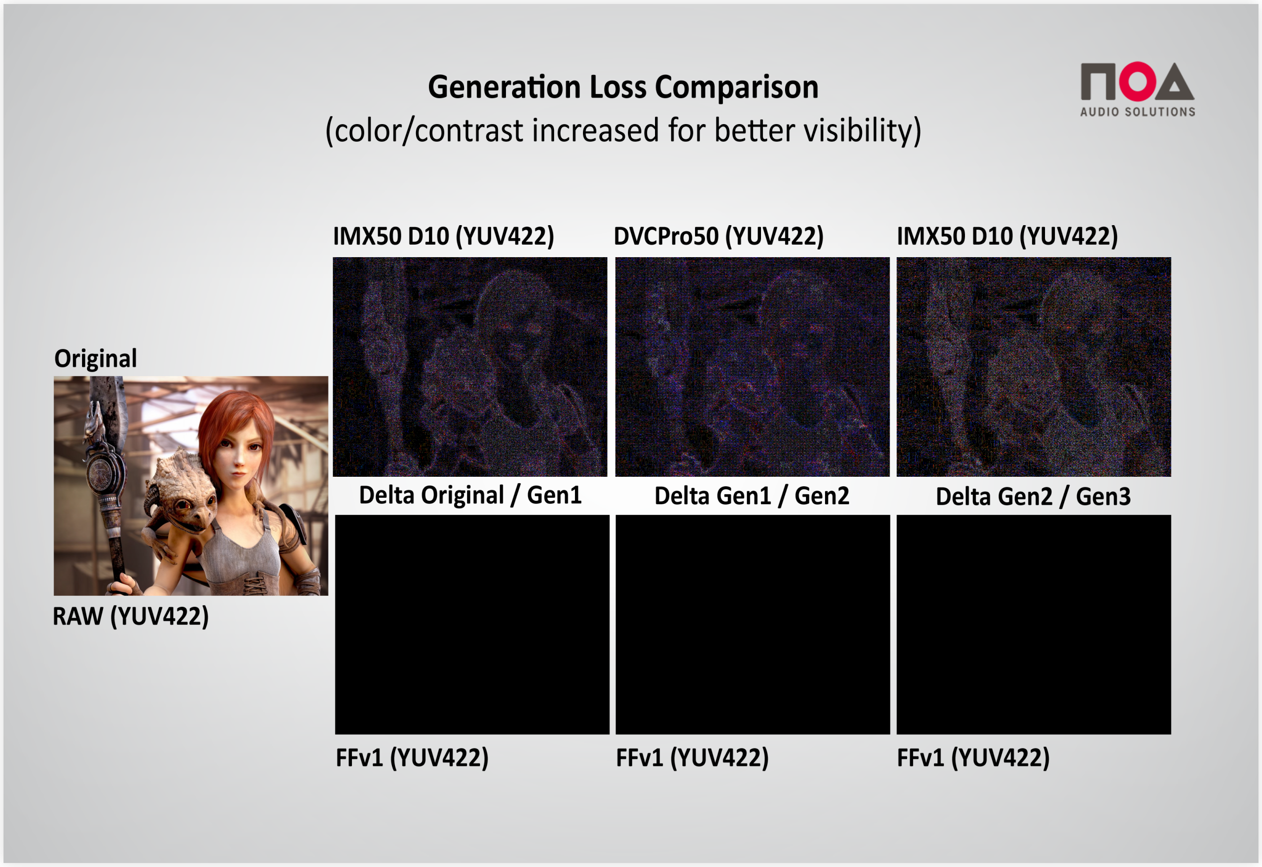
Current default = Lossy compression

Speaker notes

Of course this image is exaggerated, but it shows pretty well what lossy compression is and what artefacts a typical MPEG-like compression algorithm produces.

btw: This is a snapshot image of the highest-quality version of the video on the original website (around 2009).

Generation Loss



Generation Loss Comparison

(color/contrast increased for better visibility)

Original

RAW (YUV422)

IMX50 D10 (YUV422)

DVCPro50 (YUV422)

IMX50 D10 (YUV422)

Delta Original / Gen1

Delta Gen1 / Gen2

Delta Gen2 / Gen3

FFv1 (YUV422)

FFv1 (YUV422)

FFv1 (YUV422)

Speaker notes

Here’s an example where one can see the difference between each encoded version in popular broadcast codecs.

Uncompressed

- No generation loss
- Dead simple (=preserves well)
- The largest possible version (ca. 1.3 GB/minute PAL SD)
- There's *more* than just 1 "uncompressed"

Calculating filesize: IMAGE

- Width(px) x Height(px)
- x Bits-Per-Pixel(bpp)
- x FPS
- / 8 = **1 second (in Byte)**

Calculating filesize: AUDIO

- Samplerate x bit-depth
- x channels (even if silence!)
- / 8 = **1 second (in Byte)**

Speaker notes

So how large is an 8bpc SD PAL minute - with 4 channels audio at SDI standard (48kHz/16bit)?
Or a 2k 16bpc(!) scan (including 6 channels audio at 48kHz/24bit)?
Or 74min. of audio CD (red-book standard: 44.1kHz/16bit)?

Lossless

> *"It's like ZIP for film!"*

- No generation loss
- Way larger than lossy
- But: Smaller than uncompressed

Behind the Scenes: Algorithms

Speaker notes

There are several different algorithms used for compression. Each has its pros and cons. Here are on

Run Length Enoding (RLE)

- Uncompressed: `BBBBBBBBGGBBBBBRRRBBBB` = 19 Bytes
- Compressed: `8B2G5B3R4B` = 10 Byte

Speaker notes

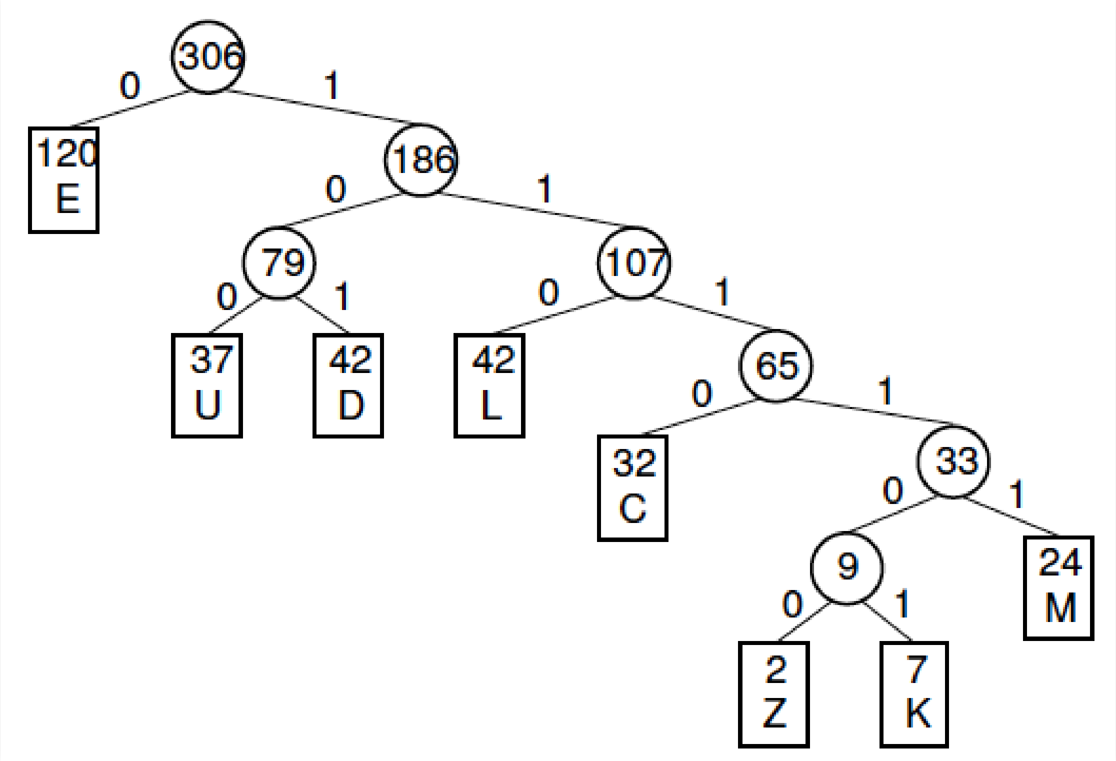
This could be seen as “delta coding”, since only *changes* between 2 characters really require space.

Huffman

Letter	Freq
E	120
D	42
L	42
U	37
C	32
M	24
K	7
Z	2

Source: Indiana University

Huffman Tree



Huffman Code

Letter	Freq	Code	Bits
E	120	0	1
D	42	101	3
L	42	110	3
U	37	100	3
C	32	1110	4
M	24	11111	5
K	7	111101	6
Z	2	111100	6

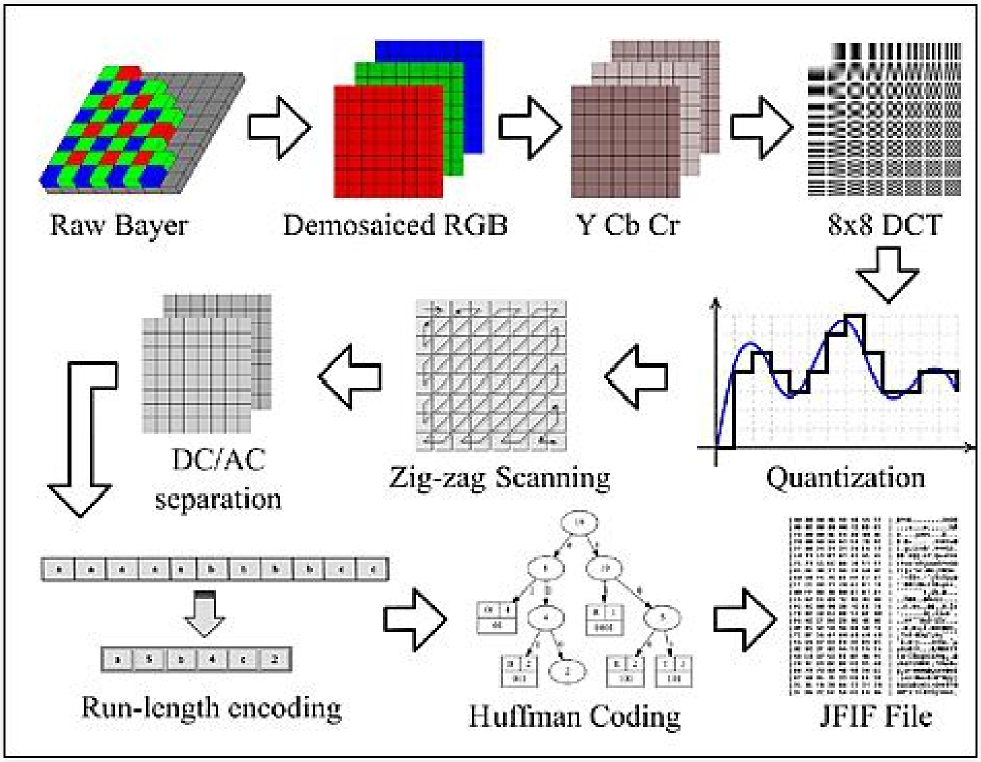
Speaker notes

Interesting: For very infrequent characters, the Huffman coding might even take more bits than an uncompressed representation.

This is especially problematic for noise signals, because: noise = chaos = no frequency pattern.

Lossy

JPEG



Terms used

- lossy
- lossless
- uncompressed
- data reduced format
- compressed
- near-lossless
- visually lossless
- mathematically lossless

Format examples: VIDEO

Lossy	**Lossless**	**Uncompressed**
MPEG-1,2,4	FFV1	v210
JPEG2000	JPEG2000	UYVY
ProRes	Dirac	YUY2
H.264	H.264	H.264
H.265	H.265	RGBA
...	...	...

Compression: Spatial and Temporal

A/V allows to apply compression in 2 ways:

- **Spatial:** Inside an image
- **Temporal:** Between images

Speaker notes

The 1st one doesn’t differ much from “image only” compression algorithms (JPEG, RLE, etc).

Temporal compression can be seen as “delta coding”, similar to RLE: You only write down what *changes* between 2 images/samples, as you would only write down what changes between 2 characters in text compression.

Spatial compression: Examples

- **Audio:** Differential pulse-code modulation (DPCM)
- **Video:** GOP, Motion estimation

Data rate / Bitrate

> *“Data per time”*

- Mbps / 8 = MB / second
- MB/s * 60 = MB / minute
- MB/min * 60 = MB / hour

Speaker notes

For lossy formats, this is a tuning parameter that can be used to adjust the final filesize and quality. For lossless or uncompressed formats, the actual bitrate can be calculated but *not* adjusted. Because the format cannot throw anything away, so there’s the bitrate is determined by content+algorithm and not a parameter.

Bitrate means “data per time”, so this means:

- Higher bitrate = larger files, but higher quality
- Lower bitrate = smaller files, but lower quality The gain of newer encoding algorithms is always to produce smaller files with higher quality.

Data rate / Bitrate

- **Higher bitrate** =
  larger files, higher quality
- **Lower bitrate** =
  smaller files, lower quality

Links

- Huffman coding (Indiana.edu)
- EETimes: Data compression tutorial: Part 1, Part 2 (LZW), Part 3 (JPEG + MPEG)
- Introduction to Data Compression (blellochcs.cmu.edu, 2013)