Daala’s advanced coding techniques
FFmpeg implementation and how they fit in AOMedia’s codec

Rostislav Pehlivanov
atomnker@gmail.com

2016-01-30
Implementing a native Daala decoder in FFmpeg

Or how I learned to stop worrying and did it anyway
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  - https://chromium-review.googlesource.com/#/q/project:webm/aom
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- Daala might become an image-only codec
  - Hopefully with support for a lossy alpha channel
Why bother?

- Google succeeded in quickly pushing their VP9 codec though Chrome(ium)
- Other browsers were slow to follow (have to ship another library)
- libvpx had speed issues
- FFVP9 was not ready on time (Firefox just switched to using it)
- ...leading to fragmentation and user agent checks for webm support
The idea

- Have support in libavcodec for AOMedia/NetVC/Daala on bitstream freezing
- Keep maintaining it and improving it until the reference implementation is stable
- That way any browser wishing to have support would only need to wait until next stable release/cherry pick.
What a normal DCT based codec does

Encoder:
- Splits image into blocks
- Does a forward DCT transform on all the blocks
- Quantized the resulting coefficients (possibly using vector quantization)
- Transmits the quantized coefficients

Decoder:
- Receives and dequantized coefficients
- Applies an inverse DCT transform
- Applies filtering (e.g. deblocking)
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Daala does pretty much everything differently...
Daala’s unique coding tools

- Entropy encoding
  - Range coding
  - Multi symbol
  - Adaptive
- Screen coding
  - Uses wavelet transforms for blocks
  - Sometimes uses Unary coding for DC coefficients
- Perceptual Vector Quantization
  - Activity masking
- Lapped transforms
- Deringing filter
- Bilinear blur for I-frames
Daala’s entropy encoder

- Unconventional - splits coding of uncompressable raw bits away
- Appends the raw bits buffer at the end of the stream
- Read/written sequentially from end to start
- Avoids the patent hell of arithmetic coding
- Codes multiple symbols
Daala’s use of wavelets for blocks

- Uses a Haar wavelet transform to compress the coefficients
- Only used on fully lossless frames currently
- Possibility to be used in a mixed block transforms (since the overlap filter is invertible)
- Very simple (able to write a decoder in around 500 lines)
Perceptual Vector Quantization

- Splits coefficients into bands (similar to audio)
- 'Synthesizes' coefficients
  - Coefficients represented by a vector
  - Each coefficient is normalized e.g. [0.0f, 1.0f]
  - Multiplied by the vector gain (transmitted separately)
- Uses standard zigzag coding for the bands
- Can accept 'reference' coefficients to use as a base
Perceptual Vector Quantization - Ref path

- Reduces coefficient delta by using the reference provided
- Uses the householder reflection to align the ref to an axis (flips sign)
- Encoder codes the difference between the current vector and the reference

- Used for Chroma from Luma
- Used for Intraprediction
- Used for Interprediction
  - Does a forward transform on the reference frame during decoding
- Can potentially be used for any other kind of prediction (e.g. alpha from luma)
Perceptual Vector Quantization - Activity Masking

- Not signalled - only a single global flag to enable
- Acts on larger blocks (4x4 have too limited quantization)
- Increases quantization on blocks with contrast (imperceptibly)
- Gives more bits to blocks with low contrast
Perceptual Vector Quantization - Without Activity Masking
Perceptual Vector Quantization - With Activity Masking
Lapped transforms

- Makes the image appear more blocky
- ’Resizes’ the block + some outside zone inside the block
Lapped transforms
Lapped transforms
Deringing

- Conditional Replacement Filter
- Ringing will usually manifest itself as noise above the quantization step
- Picks a center pixel and scans every pixel around it
- If a pixel is deviating above the quantization step, replace it with the value of the center pixel.
Deringing
Deringing
FFmpeg Daala decoder

- Can decode Daala I-frames only
- Some code written from scratch, most is rewritten libdaala
- Still no support for the deringing filter
- Still some artifacts with 64x64 transforms
- Fully templated DSP
- But nearly bit identical
The End
Questions?