SCALABLE TRELLIS QUANTIZATION FOR JPEG XS

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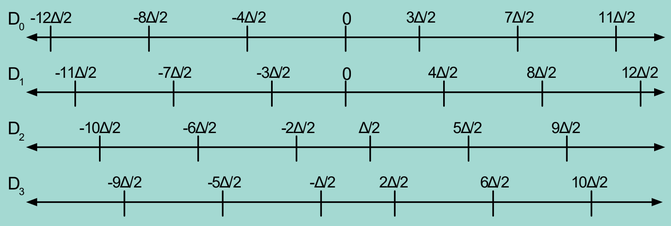
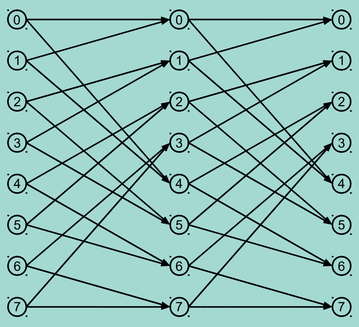
ABSTRACT
Trellis quantization as structured vector quantization improves the performance of JPEG XS while retaining the simplicity of the XS rate allocation process. A scalable Trellis quantization and rate allocation is proposed.

BACKGROUND
The proposed Trellis quantizer consists of four uniform scalar quantizers D_0 to D_3 and a state machine dependent on the parity of the bucket index to switch between them, similar to JPEG 2000 (15444-2).



Quantizers from which the trellis is constructed


Trellis state transitions

Parity / State	even	odd
0 1 4 5	D_0	D_2
2 3 6 7	D_1	D_3

Quantizer selection by state and parity

RATE ALLOCATION
Observation: Rate of the trellis quantizer in case of „embedded sign coding“ is identical to scalar case if the quantization bucket index remains bounded by 2^{M-T}. Reflect „out of bounds“ buckets back into the limiting range.

$$\Delta_T = 2^{T+1}\left(\frac{2^{M+1-T}}{2^{M+1-T}-1}\right)$$

Quantizer bucket size for truncation position T, bitplane count M, for one coding group.
Rate is 4(M-T+1)

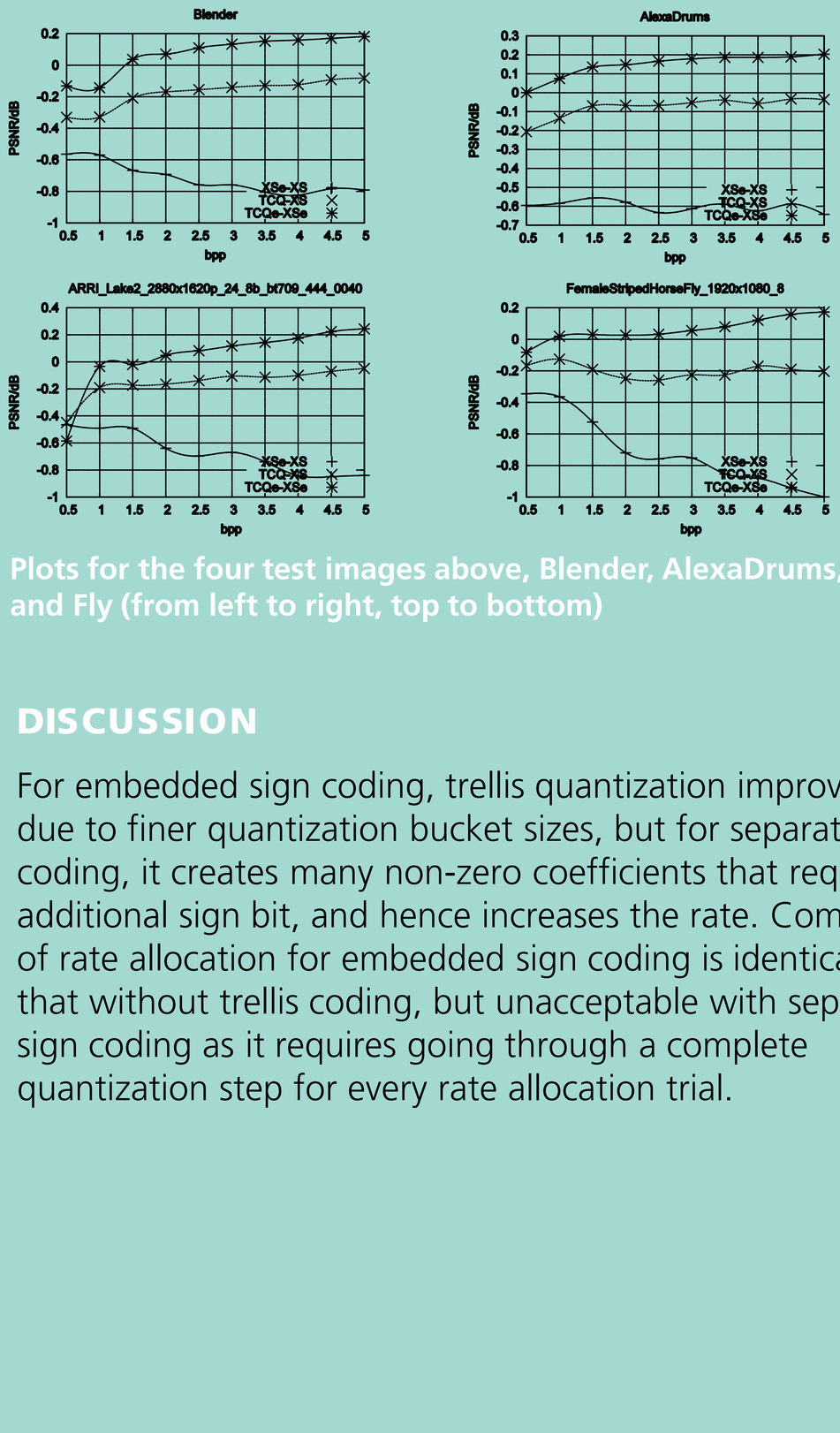
Reconstruction points beyond the available rate (here T=M-2) are reflected back into the available range, and are thus unlikely picked by the trellis upon quantization.

SIGN CODING
For separate sign coding, the signs (red) are only coded if the quantizer bucket index is non-zero.

EXPERIMENTS
On the JPEG XS test image set (natural, CGI images), PSNR differences between embedded and separate sign coding, and with and without trellis coding.


Images used for testing

RESULTS
About 0.2dB gain for enabling trellis coding in the embedded sign coding case, about 0.1dB loss in the separate sign coding case. Embedded coding is generally less performing than separate sign coding (expected), though less complex.



Plots for the four test images above, Blender, AlexaDrums, Lake and Fly (from left to right, top to bottom)

DISCUSSION
For embedded sign coding, trellis quantization improves PSNR due to finer quantization bucket sizes, but for separate sign coding, it creates many non-zero coefficients that require an additional sign bit, and hence increases the rate. Complexity of rate allocation for embedded sign coding is identical to that without trellis coding, but unacceptable with separate sign coding as it requires going through a complete quantization step for every rate allocation trial.

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