JCTVC-C073

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TE2: Reference Frame Compression using Image Coder

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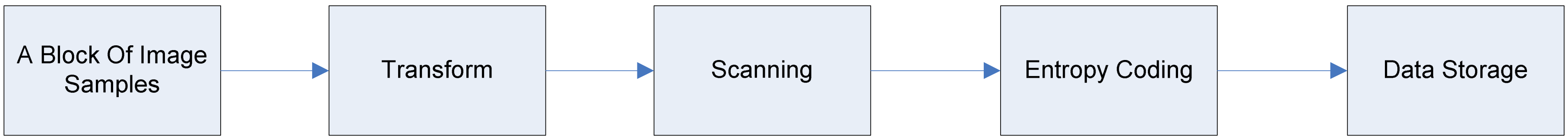
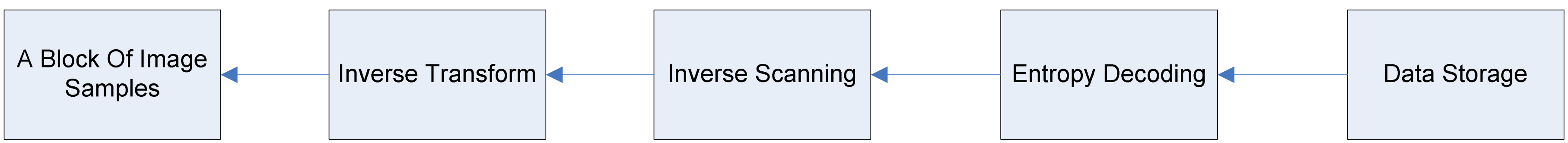
Introduction

- Reference frame compression (RFC) based on image coder was proposed by Panasonic in Geneva meeting (JCTVC-B103).
- After Geneva meeting, proposed RFC was implemented into TMuC v0.7.3 and evaluated as part of TE2.
- This contribution (JCTVC-C073) presents the implementation details and results of RFC.

RFC Encoding & Decoding Schemes



JCTVC-B103 Figure 2: Reference Frame Compression Scheme



JCTVC-B103 Figure 3: Reference Frame Decompression Scheme

Implementation Details

- *Compression unit*
  - 4x4 block of luma pixels
  - Two corresponding 2x2 blocks of chroma pixels
- *Transform*
  - Sequency-ordered Hadamard transform
  - Transform normalization (by a factor of 1/N for an NxN block) at reference frame compression is moved to reference frame decompression stage, where normalization factor becomes 1/(NxN).
- *Scanning*
  - Zig-zag scan to map from 2D to 1D

Implementation Details

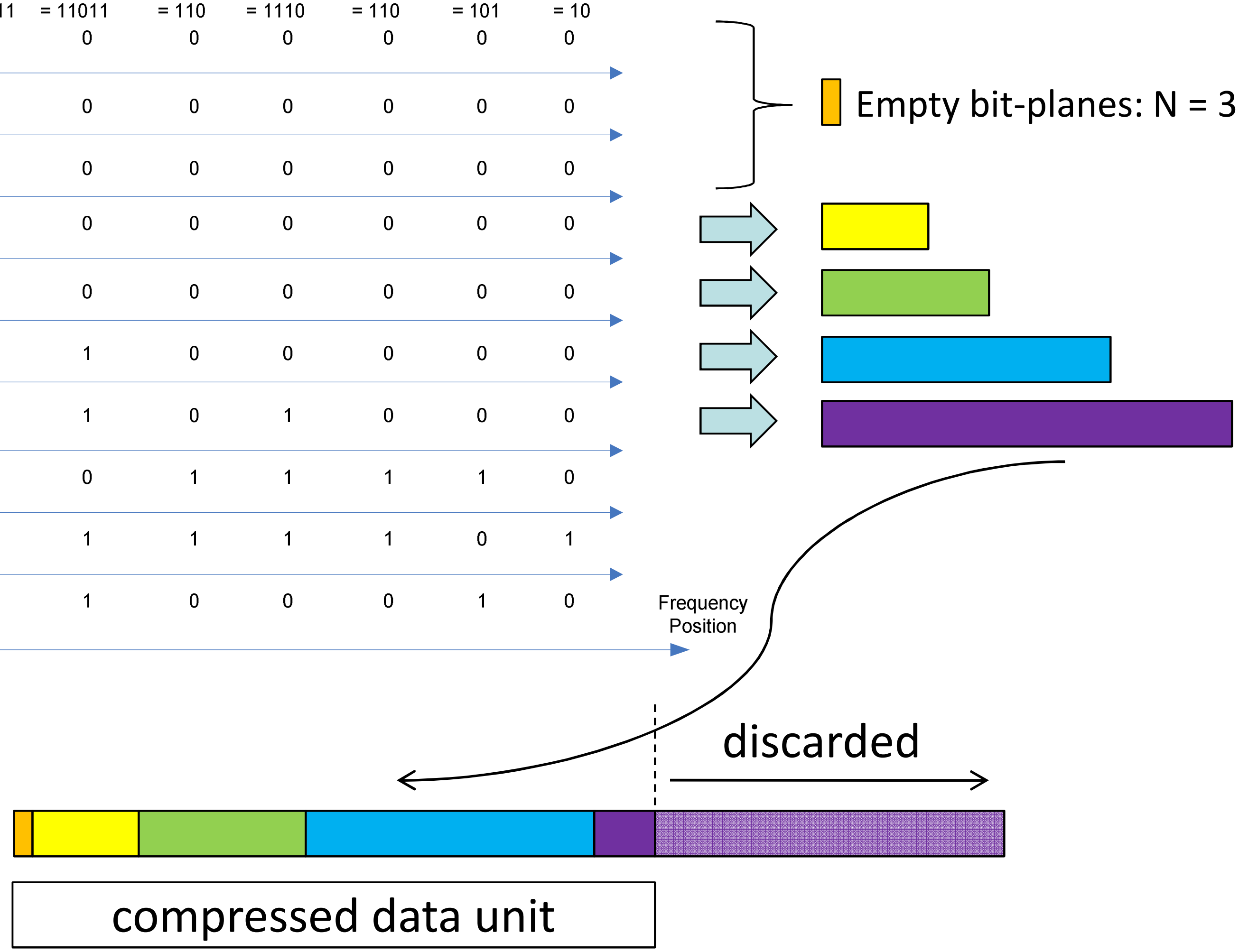
- *Entropy coding*
  - Bit-plane coding is used in current design.
  - Quite similar to MPEG-4 FGS with *EOP*, *run*, *sign*.
  - Only *run* is coded in unary code. Other parameters (*EOP*, *sign*, *non-MSB*) are coded in binary bits.

- *Combined bit-plane coding for luma & chroma*
  - Combined bit-plane coding gives better compression efficiency. Bit allocation between luma & chroma within a compressed data unit is flexible.
  - Overall bit balance between luma and chroma data is adjusted by up-shifting chroma transform coefficients by 2 bit-planes (equivalent to multiplication by 4).

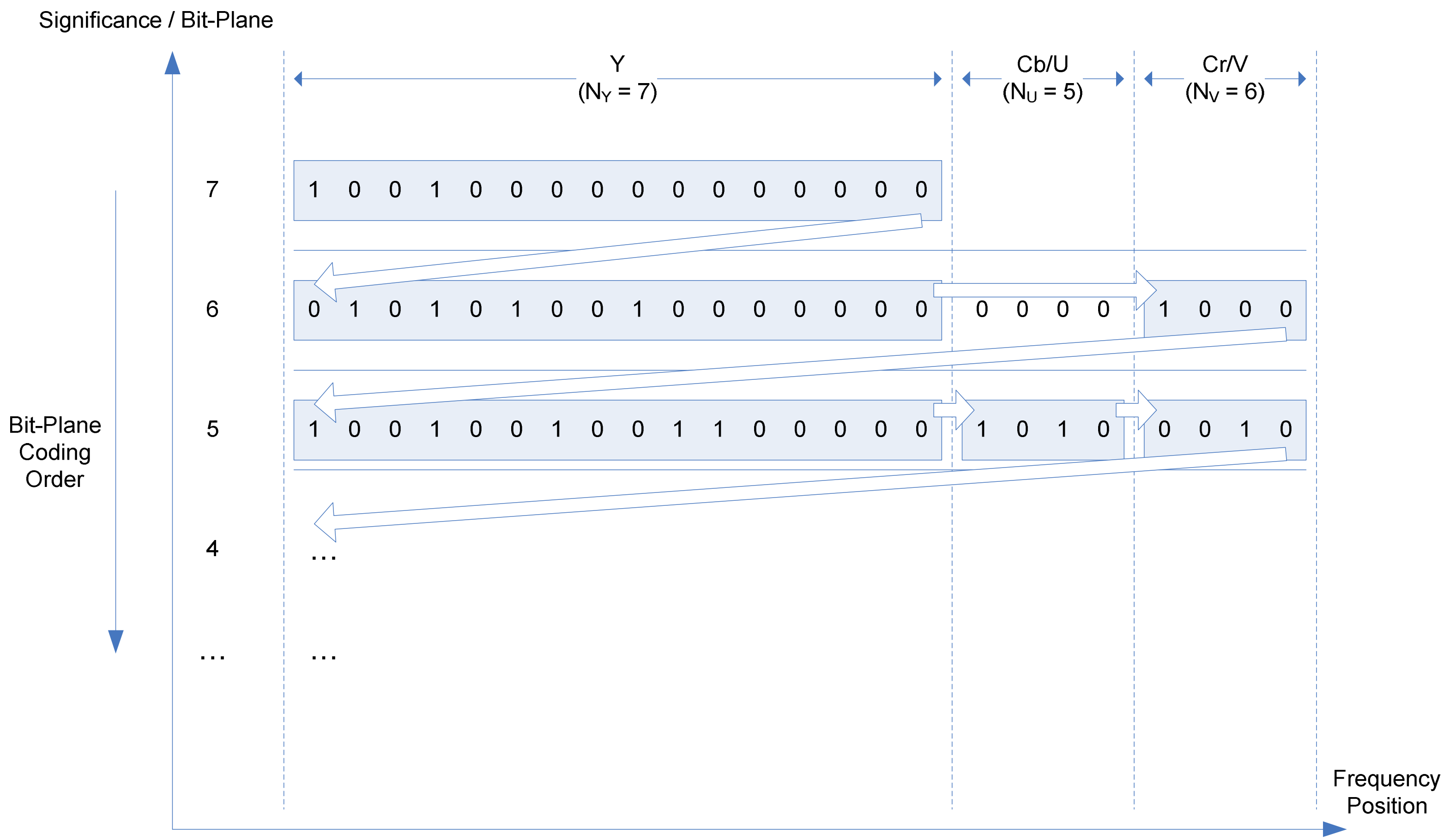
Bit-Plane Coding

Significance ↑ / Bit-Plane Coding Order ↓ / Frequency Position →

Sign = 1 Abslevel = 102 Binary = 1100110	Sign = 0 Abslevel = 47 Binary = 101111	Sign = 0 Abslevel = 27 Binary = 11011	Sign = 1 Abslevel = 6 Binary = 110	Sign = 0 Abslevel = 14 Binary = 1110	Sign = 1 Abslevel = 6 Binary = 110	Sign =0 Abslevel = 5 Binary = 101	Sign = 1 Abslevel = 2 Binary = 10
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0
1	1	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	1	1	0	1	0	0	0
1	1	0	1	1	1	1	0
1	1	1	1	1	1	0	1
0	1	1	0	0	0	1	0



Combined Luma & Chroma



JCTVC-C073 Figure 3: Combined bit-plane coding for luma and chroma data

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Experiment Details

- Test conditions
  - Same as TE2 conditions
- Source code version
  - Anchor is TMuC version 0.7.3 revision 188.
  - RFC is implemented onto anchor TMuC version.
- Compression ratios:

$$\text{compression ratio} = \frac{\text{compressed size}}{\text{uncompressed size}}$$

  - High Efficiency, Random Access: 12-bit to 5.33-bit (44.4% ratio)
  - High Efficiency, Low Delay: 12-bit to 5.33-bit (44.4% ratio)
  - Low Complexity, Random Access: 8-bit to 5.33-bit (66.7% ratio)
  - Low Complexity, Low Delay: 8-bit to 5.33-bit (66.7% ratio)
- Output compressed data size from each compression unit
  - High Efficiency: 16 bytes, from uncompressed 36 bytes (24B luma, 12B chroma)
  - Low Complexity: 16 bytes, from uncompressed 24 bytes (16B luma, 8B chroma)

Experimental Results

Random Access, High Efficiency (12-bit to 5.33-bit)

Image	Coding Efficiency			Memory Access Bandwidth [addressing/burst]			
	Y BD-rate	U BD-rate	V BD-rate	32bit/64bit	64bit/128bit	128bit/128bit	256bit/256bit
Class A	1.7%	4.1%	5.5%	-44.6%	-50.4%	-54.3%	-62.0%
Class B	2.1%	6.2%	10.4%	-46.3%	-51.4%	-54.4%	-60.6%
Class C	3.9%	6.5%	8.6%	-44.6%	-50.6%	-54.6%	-61.5%
Class D	3.5%	10.7%	11.5%	-42.1%	-49.1%	-53.9%	-61.6%
All	2.9%	7.2%	9.6%	-44.5%	-50.5%	-54.3%	-61.3%
Enc Time	103%						
Dec Time	197%						

Low Delay, High Efficiency (12-bit to 5.33-bit)

Image	Coding Efficiency			Memory Access Bandwidth [addressing/burst]			
	Y BD-rate	U BD-rate	V BD-rate	32bit/64bit	64bit/128bit	128bit/128bit	256bit/256bit
Class B	2.9%	6.0%	10.5%	-45.0%	-50.9%	-54.7%	-61.6%
Class C	5.3%	6.6%	8.2%	-43.2%	-50.0%	-54.6%	-61.7%
Class D	4.3%	10.9%	11.4%	-42.1%	-50.1%	-55.6%	-63.3%
Class E	7.6%	12.9%	15.3%	-50.2%	-53.6%	-55.6%	-62.3%
All	4.7%	8.7%	11.0%	-44.8%	-51.0%	-55.1%	-62.2%
Enc Time	102%						
Dec Time	200%						

Experimental Results

Random Access, Low Complexity (8-bit to 5.33-bit)

Image	Coding Efficiency			Memory Access Bandwidth [addressing/burst]			
	Y BD-rate	U BD-rate	V BD-rate	32bit/64bit	64bit/128bit	128bit/128bit	256bit/256bit
Class A	2.0%	1.9%	3.5%	-25.0%	-38.5%	-45.8%	-55.0%
Class B	2.3%	2.6%	4.9%	-26.9%	-39.1%	-44.5%	-54.2%
Class C	3.5%	4.2%	6.2%	-26.6%	-40.2%	-46.7%	-56.7%
Class D	3.3%	6.4%	8.9%	-24.5%	-39.8%	-47.5%	-58.0%
All	2.9%	3.9%	6.1%	-25.9%	-39.5%	-46.1%	-56.0%
Enc Time	102%						
Dec Time	214%						

Low Delay, Low Complexity (8-bit to 5.33-bit)

Image	Coding Efficiency			Memory Access Bandwidth [addressing/burst]			
	Y BD-rate	U BD-rate	V BD-rate	32bit/64bit	64bit/128bit	128bit/128bit	256bit/256bit
Class B	3.1%	2.8%	4.1%	-25.8%	-40.3%	-46.7%	-56.4%
Class C	4.3%	4.3%	6.7%	-25.1%	-41.2%	-48.2%	-58.7%
Class D	3.7%	5.9%	6.6%	-22.7%	-42.1%	-50.2%	-60.7%
Class E	5.4%	5.3%	5.2%	-29.5%	-36.9%	-41.7%	-50.0%
All	4.0%	4.4%	5.6%	-25.5%	-40.3%	-47.0%	-56.9%
Enc Time	100%						
Dec Time	211%						

Conclusion

- In comparison with anchor (TMuC v0.7.3):
  - High Efficiency, Random Access: BD-rate increase of 2.9% (Y), 7.2% (U), 9.6% (V) at 44.4% ratio
  - High Efficiency, Low Delay: BD-rate increase of 4.7% (Y), 8.7% (U), 11.0% (V) at 44.4% ratio
  - Low Complexity, Random Access: BD-rate increase of 2.9% (Y), 3.9% (U), 6.1% (V) at 66.7% ratio
  - Low Complexity, Low Delay: BD-rate increase of 4.0% (Y), 4.4% (U), 5.6% (V) at 66.7% ratio
- We note that current implementation of bit-plane coding has high complexity. Future efforts will be to reduce such complexity.

Thank you