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Reference Frame Compression Using Image Coder

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Agenda

- Introduction
- Challenges For Reference Frame Compression Design
- Reference Frame Compression (RFC)
  - Basic Concept
  - Basic Coding Structure
  - Proof Of Concept
- Experimental Details
- Results
- Conclusion

Introduction

- *Why reference frame compression?*
  - Reduce memory access bandwidth
  - Reduce memory size required for storing reconstructed pictures

- *Why standardize reference frame compression?*
  - It exists in some decoder implementations today.
  - Mismatch & drift occurs if it is not standardized.
  - New video standard targets new applications supporting large resolution (e.g. 4k by 2k). Memory access bandwidth will be an issue for implementation.

- *Why JCT-VC?*
  - Reference frame compression is just a simple image coder.
  - Best design by experts.
  - Possibility for synergic in design with video compression.

Challenges For RFC

- *Required functionalities.*
  - Random accessibility of each memory block.
  - Fixed data size for compressed block.
  - Low complexity for both compressor and decompressor.
  - Small block size for minimizing overheads.

- *Challenges*
  - Each data block is self-contained. No dependency on neighboring blocks for decompression.
  - Size of the block (overhead versus coding gain).
  - Low complexity.

Basic Coding Structure

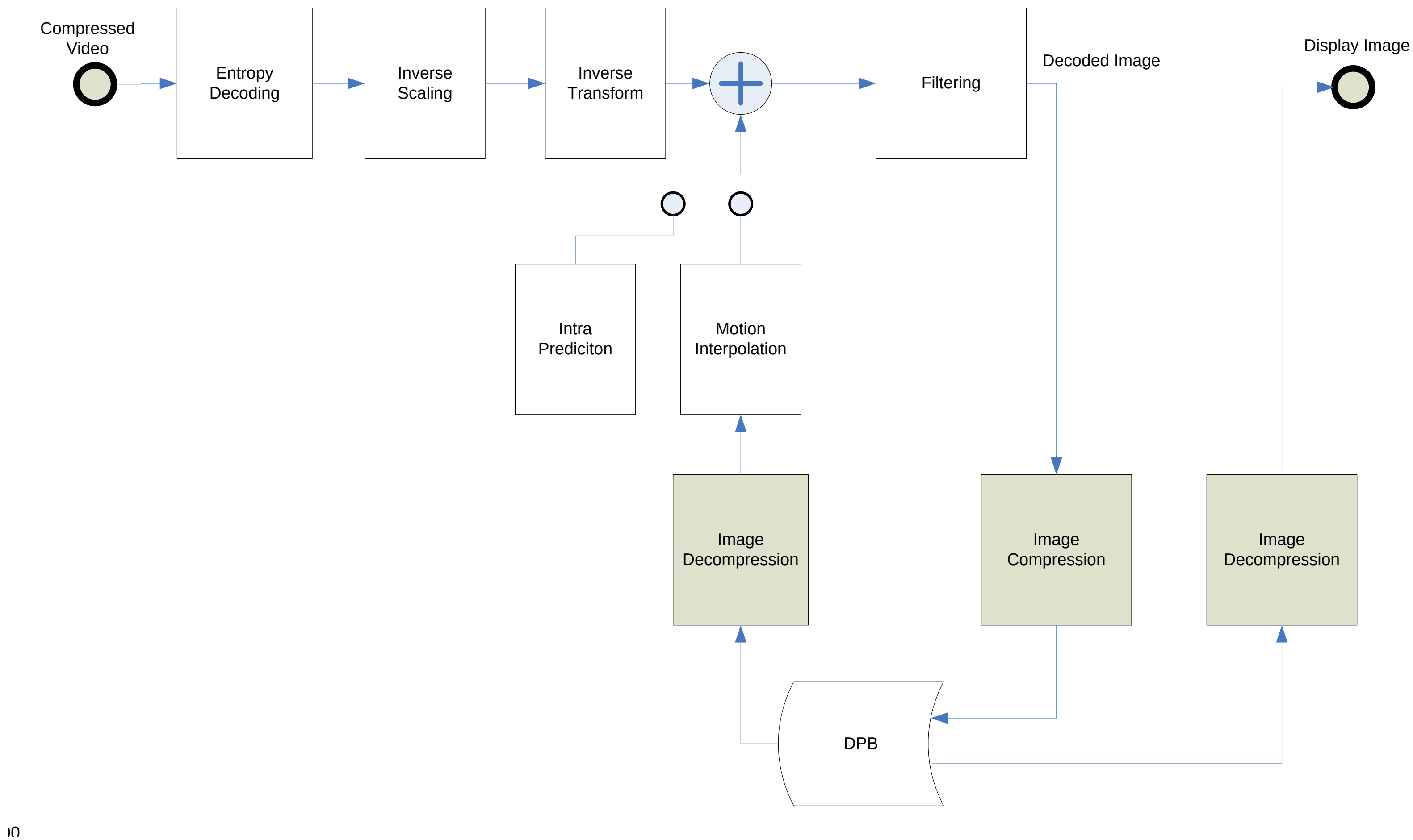


Figure 1: Basic Coding Structure Using Reference Frame Compression

Encoding And Decoding Schemes

Figure 2: Reference Frame Compression Scheme

Figure 3: Reference Frame Decompression Scheme

Proof Of Concept

- ***Transform***
  - Floating point DCT is used in the simulation.
  - But a simple integer transform should be used in the final design
- ***Scanning***
  - Mapping from 2D to 1D (zig-zag like scanning)
- ***Entropy coding***
  - Bit plane coding is used in the simulation.
  - Quite similar to MPEG-4 FGS with EOP, Run, Signed Bit.
  - Only run parameter is coded in variable length code (Exp-Golomb code). The rest of parameters are coded in binary bits.
- ***Combined bit plane coding with chroma samples.***
  - Assumes dependency in motion vectors and interpolation filter tap length.
  - Bits allocation between luma and chroma samples can be made flexible in some design.

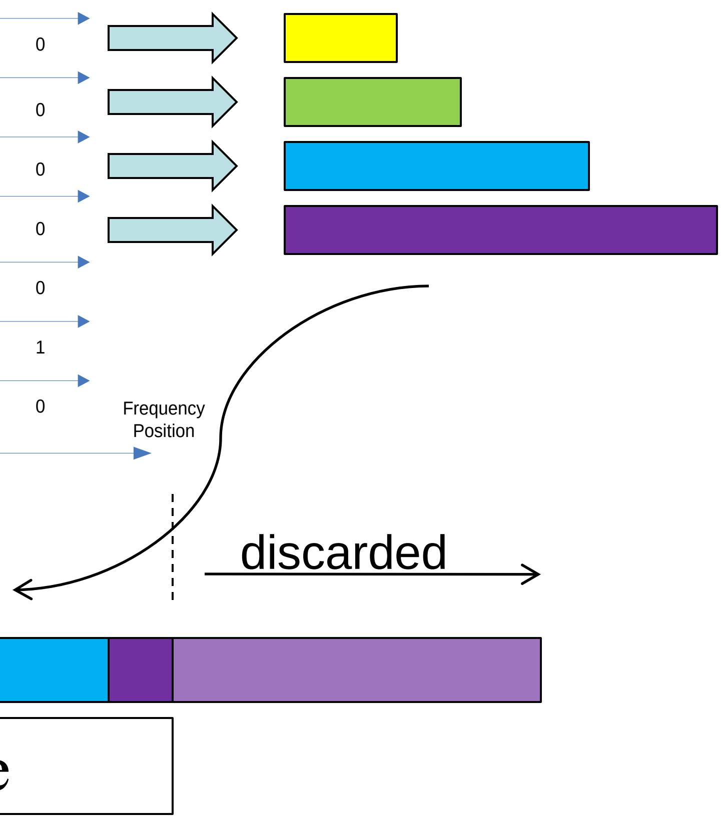
Bit Plane Coding

Significant

Bit Plane coding Order

Signed Bit = 1 Abslevel = 102 Binary = 1100110	Signed Bit = 0 Abslevel = 47 Binary = 101111	Signed Bit = 0 Abslevel = 27 Binary = 11011	Signed Bit = 1 Abslevel = 6 Binary = 110	Signed Bit = 0 Abslevel = 14 Binary = 1110	Signed Bit = 1 Abslevel = 6 Binary = 110	Signed Bit =0 Abslevel = 5 Binary = 101	Signed Bit = 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

Frequency Position



Experimental Details

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- Experiments were conducted using four settings:
  - JM 16.2
  - TMuC revision 25
  - TMuC revision 25 + RFC 50% (50% size reduction)
  - TMuC revision 25 + RFC 67% (33% size reduction)
- The block size (4:2:0) is set as:
  - Y component: 8x4 samples
  - U and V components: 4x2 samples for each
- The output size from coding each block is set as:
  - For 50% size reduction: 24 bytes for each block
  - For 33% size reduction: 32 bytes for each block
- Test conditions
  - Similar to TE2 conditions. (except for Kimono)

Experimental Results

CS1: 5 points BD Rate Compared To JM 16.2

Class	Resolution	Seq. No	Seq. Name	TMuC_R25	TMuC_R25 +RFC(50%)	Diff	TMuC_R25 +RFC(67%)	Diff
A	4K	S01	Traffic	33.59%	32.58%	-1.01%	33.37%	-0.22%
		S02	PeopleOnStreet	26.38%	26.33%	-0.05%	26.35%	-0.03%
B	1080p	S03	Kimono	46.33%	46.31%	-0.02%	46.34%	0.01%
		S04	ParkScene	33.13%	32.42%	-0.71%	32.99%	-0.14%
		S05	Cactus	36.22%	35.35%	-0.87%	36.04%	-0.18%
		S06	BasketballDrive	45.79%	45.68%	-0.11%	45.77%	-0.02%
		S07	BQTerrace	48.80%	46.98%	-1.82%	48.43%	-0.37%
C	WVGA	S08	BasketballDrill	37.48%	36.23%	-1.25%	37.26%	-0.22%
		S09	BQMall	29.53%	28.84%	-0.69%	29.49%	-0.04%
		S10	PartyScene	34.29%	33.17%	-1.12%	34.07%	-0.22%
		S11	RaceHorses	29.33%	28.57%	-0.76%	29.14%	-0.19%
D	WQVGA	S12	BasketballPass	25.88%	24.13%	-1.75%	25.51%	-0.37%
		S13	BQSquare	45.36%	40.62%	-4.74%	44.81%	-0.55%
		S14	BlowingBubbles	27.47%	23.75%	-3.72%	26.80%	-0.67%
		S15	RaceHorses	22.66%	20.08%	-2.58%	22.17%	-0.49%
E	720P	S16	Vidyo1					
		S17	Vidyo3					
		S18	Vidyo4					
All			Average	34.82%	33.40%	-1.42%	34.57%	-0.25%
			Difference			-1.42%		-0.25%

Experimental Results

CS2: 5 points BD Rate Compared To JM 16.2

Class	Resolution	Seq. No	Seq. Name	TMuC_R25	TMuC_R25 +RFC(50%)	Difference	TMuC_R25 +RFC(67%)	Difference
A	4K	S01	Traffic					
		S02	PeopleOnStreet					
B	1080p	S03	Kimono	27.45%	27.36%	-0.09%	27.49%	0.04%
		S04	ParkScene	21.03%	20.51%	-0.52%	20.97%	-0.06%
		S05	Cactus	20.34%	19.66%	-0.68%	20.15%	-0.19%
		S06	BasketballDrive	33.97%	33.89%	-0.08%	34.03%	0.06%
		S07	BQTerrace	36.68%	35.43%	-1.25%	36.44%	-0.24%
C	WVGA	S08	BasketballDrill	26.41%	25.43%	-0.98%	26.11%	-0.30%
		S09	BQMall	16.62%	16.05%	-0.57%	16.39%	-0.23%
		S10	PartyScene	30.67%	29.95%	-0.72%	30.60%	-0.07%
		S11	RaceHorses	11.24%	10.85%	-0.39%	11.29%	0.05%
D	WQVGA	S12	BasketballPass	10.34%	9.16%	-1.18%	10.28%	-0.06%
		S13	BQSquare	28.92%	25.53%	-3.39%	28.39%	-0.53%
		S14	BlowingBubbles	14.31%	11.67%	-2.64%	13.90%	-0.41%
		S15	RaceHorses	1.31%	-0.93%	-2.24%	0.78%	-0.53%
E	720P	S16	Vidyo1	32.77%	32.55%	-0.22%	32.87%	0.10%
		S17	Vidyo3	22.07%	21.89%	-0.18%	22.00%	-0.07%
		S18	Vidyo4	27.78%	27.68%	-0.10%	27.93%	0.15%
All			Average	22.62	21.67	-0.95	22.48	-0.14
			Difference			-0.95		-0.14

Conclusion

- In comparison with the TMuC software without RFC,
  - Using RFC (50% size reduction)
    - -1.41% in the average coding gain over JM16.2 for CS1
    - -0.25% in the average coding gain over JM16.2 for CS2
  - Using RFC (33% size reduction)
    - -0.95% in the average coding gain over JM16.2 for CS1
    - -0.14% in the average coding gain over JM16.2 for CS2
- Image coding approach can provide good compression efficiency for RFC especially for the large resolution sequences.
- We recommend JCT-VC to consider
  - standardizing an image coder for reference frame compression,
  - the co-design of the reference image coder and the interpolation filter to reduce the overall memory access bandwidth for next generation video coding.

Questions?