JCTVC-M0182
COMPLEXITY ANALYSIS OF SHM1.0

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13th JCT-VC meeting, April 2013

Introduction

- AHG17 "SHVC complexity assessment" was established at the 12th JCTVC meeting
  - Study memory bandwidth, memory usage and computational complexity of scalable tools and methodologies to evaluate them

- After meeting, a group of companies worked together to provide complexity assessment data for SHM1.0 anchors
  - Released in JCTVC-L0440 in Feb
  - Used by SCE3 and SCE4 to assess complexity of individual coding tools

- JCTVC-L0440 package includes complexity data for the following solutions:
  - SHM1.0 ref_idx: PU-based and Picture-based
  - SHM1.0 IntraBL
  - HM8.1 simulcast

- This contribution provides complexity analysis summary of SHM1.0 based on JCTVC-L0440

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AHG17 complexity assessment methodologies

- Complexity is measured considering the following:
  - Temporal MCP in BL and EL, and inter layer prediction
  - Memory bandwidth: 8b/8b (pure), 64b/256b (DDR-2), 64b/512b (DDR-3)
  - Computational complexity: adds, mults

- SHM1.0 RefIdx solution supports two types of implementations:
  - Picture based: upsample and store inter layer reference in DPB, minimal re-design of EL decoder
  - PU based: on-the-fly upsampling

- SHM1.0 IntraBL solution supports one type of implementation:
  - Block based: on-the-fly upsampling

- Average complexity tallied by decoding the actual bitstreams

- Worst case complexity calculated based on peak memory access

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Summary of Average Complexity (RA/LDP/LDB)

Average complexity for RA/LDP/LDB test cases, compared with HM8.1 simulcast

		Memory bandwidth			# calculations	
		8b/8b	64b/256b	64b/512b	Mults	Adds
IntraBL		92%	94%	93%	94%	94%
RefIdx	PU-based	92%	93%	92%	95%	95%
	Pic-based	103%	101%	101%	144%	144%

1. PU-based RefIdx implementation very similar complexity as IntraBL (±1%)
2. Pic-based RefIdx implementation higher complexity than block based implementation
   - Upsampling performed for all blocks regardless of whether they are used by EL
   - Complexity increase related to spatial ratios: 2x > 1.5x > SNR

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Summary of Average Complexity (AI)

Average complexity for AI test cases, compared with SHM1.0 IntraBL

	Memory bandwidth			# calculations	
	8b/8b	**64b/256b**	**64b/512b**	**Mults**	**Adds**
PU-based RefIdx	91%	89%	89%	98%	98%
Pic-based RefIdx	56%	42%	43%	98%	98%

1. HM8.1 Simulcast not suitable as reference in AI test cases
   - No temporal MCP in BL and EL
2. PU-based RefIdx implementation somewhat lower complexity than IntraBL
3. Pic-based RefIdx implementation significantly lower complexity in terms of memory bandwidth
   - Picture-based upsampling has fixed memory bandwidth overhead
   - In AI, more blocks in EL use inter layer prediction
   - Reduced average complexity

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Worst case complexity

	HM8.1	IntraBL			PU-based RefIdx			Pic-based RefIdx		
	MC @ EL	Upsampling	% of HM8.1		Upsampling	% of HM8.1		Upsampling	% of HM8.1	
Mult	74	37	50%		37	50%		24	32%	
Adds	63	32	51%		32	51%		21	33%	
MemBand (2D:4x2)	18	9	50%		12	67%		4	22%	
MemBand (2D:8x2)	27	14	52%		18	67%		5	19%	

1. Only includes spatial scalability (2x and 1.5x)
2. Anchor is temporal MCP in HEVC
3. PU-based RefIdx has higher memory bandwidth
    - PU based rather than CU-based inter layer prediction
4. Pic-based RefIdx has lower complexity
    - No peak complexity, whole picture always upsampled
    - Calculated assuming 16x16 blocks

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Conclusion

- IntraBL can be implemented as block-based

- RefIdx can be implemented either as block-based, or as picture-based
  - Picture-based implementation allows to re-use single layer codec design for the EL

- Block based RefIdx and IntraBL have similar complexity characteristics
  - Average complexity and worst case complexity

- Picture-based RefIdx implementation has very different complexity characteristics:
  - Average complexity: lower for AI, higher (esp computation) for RA/LDP/LDB
  - Worst case complexity: lower complexity

		Average Complexity		Worst case complexity
		AI	RA/LDP/LDB	
IntraBL			X	
RefIdx	PU-based		X	
	Pic-based	X		X

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