JCT3V-E0142 – CE2.h related: Simplified NBDV and Improved DV derivation

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List of Proposed Methods

- ❖ Method 1: Simplified NBDV
- ❖ Method 2: Improved DV derivation
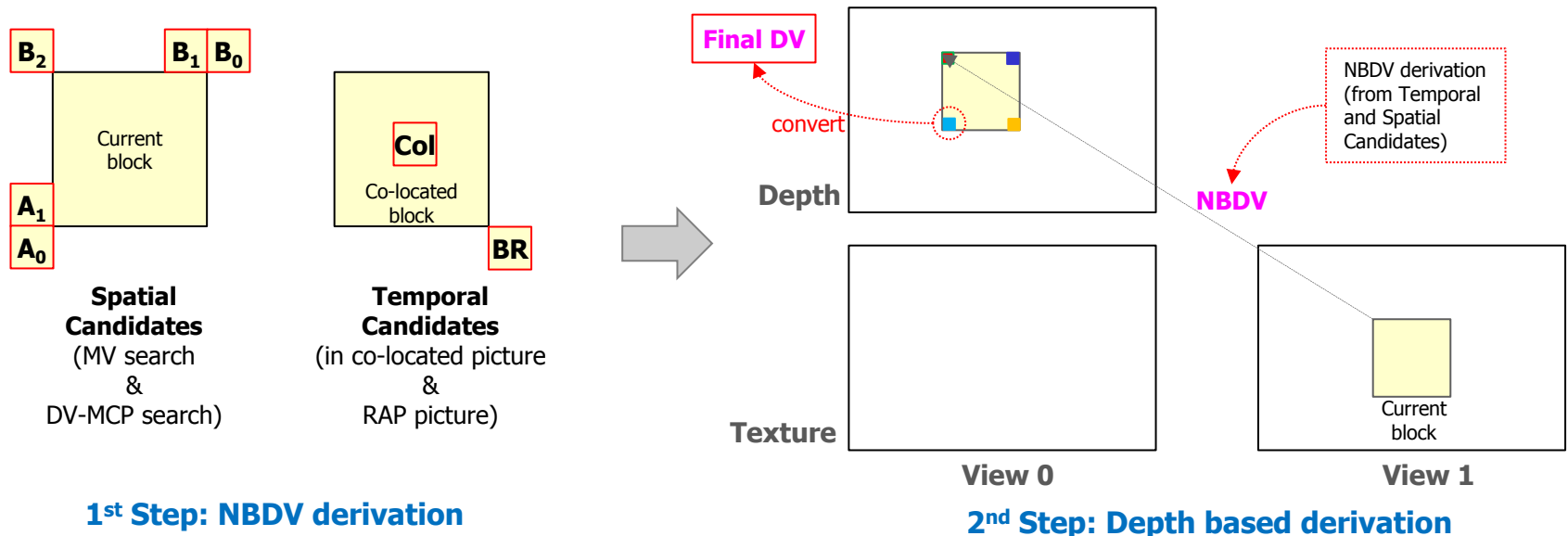- ❖ Method 3: Using unavailable DV for ARP

Current DV Derivation

- ❖ 1st Step: <u>NBDV derivation</u>
  - ▪ Temporal candidate search: BR and Col in co-located pic. and RAP pic.
  - ▪ Spatial candidate search: A_1, B_1, B_0, A_0, and B_2
  - ▪ DV-MCP: A_1, B_1, B_0, B_1, and B_2
- ❖ 2nd Step: <u>Depth based derivation</u>
  - ▪ Find corresponding depth block by using **NBDV**
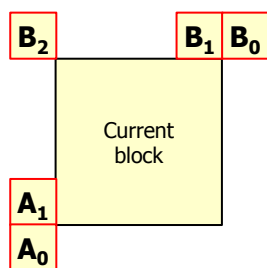 - ▪ Max. depth value among 4 corner pixels of the depth block ➜ **Final DV**

1st Step: NBDV derivation

2nd Step: Depth based derivation

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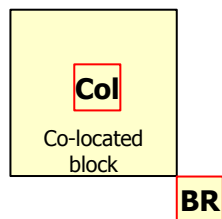# Simplified NBDV (1)

❖ 1st Step: <u>Simplified</u> NBDV derivation

- ▪ Temporal candidate search: ~~BR and~~ Col in co-located pic. and RAP pic.
- ▪ Spatial candidate search: A_1, B_1~~, B_0, A_0, and B_2~~
- ▪ DV-MCP: A_1, B_1~~, B_0, B_1, and B_2~~

❖ 2nd Step: <u>Depth based derivation</u>

- ▪ Find corresponding depth block by using **Simplified NBDV**
- ▪ Max. depth value among 4 corner pixels of the depth block ➔ **Final DV**
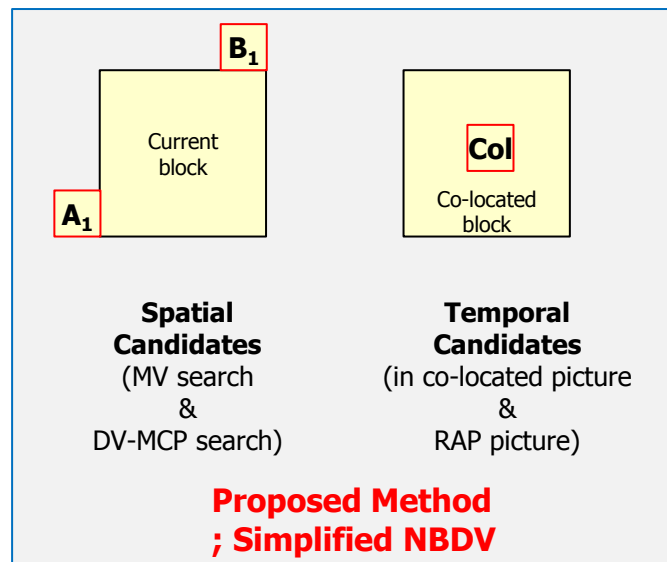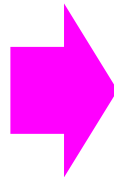
Simplified NBDV (2)

❖ Experimental results (**CTC**)

- Based on HTM 7.0r1
- No coding loss
  (0.01% and 0.04% bit-saving in coded and synthesized views)

	video 0	video 1	video 2	video PSNR / video bitrate	video PSNR / total bitrate	synth PSNR / total bitrate	enc time	dec time	ren time
Balloons	0.00%	-0.03%	-0.03%	-0.02%	-0.02%	0.00%	99.7%	91.6%	98.6%
Kendo	0.00%	0.21%	-0.05%	0.04%	0.04%	0.05%	100.7%	96.4%	100.8%
Newspaper_CC	0.00%	-0.19%	-0.28%	-0.07%	-0.05%	-0.31%	100.1%	95.7%	100.0%
GT_Fly	0.00%	0.10%	-0.07%	0.00%	0.00%	0.00%	100.2%	99.1%	102.7%
Poznan_Hall2	0.00%	0.08%	0.15%	0.04%	0.04%	0.06%	100.0%	98.8%	100.8%
Poznan_Street	0.00%	-0.25%	-0.08%	-0.05%	-0.05%	-0.04%	99.4%	95.7%	100.1%
Undo_Dancer	0.00%	-0.08%	0.04%	-0.01%	-0.02%	-0.02%	99.9%	103.1%	98.9%
1024x768	0.00%	0.00%	-0.12%	-0.02%	-0.01%	-0.09%	100.2%	94.6%	99.8%
1920x1088	0.00%	-0.04%	0.01%	0.00%	-0.01%	0.00%	99.9%	99.2%	100.7%
average	**0.00%**	**-0.02%**	**-0.05%**	**-0.01%**	**-0.01%**	**-0.04%**	**100.0%**	**97.2%**	**100.3%**

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Simplified NBDV (3)

❖ Experimental results (**non-CTC; BVSP and DoNBDV off**)

- Based on HTM 7.0r1
- 0.15% gain in video 1
- No coding loss
  (0.02% and 0.01% bit-saving in coded and synthesized views)

	video 0	video 1	video 2	video PSNR / video bitrate	video PSNR / total bitrate	synth PSNR / total bitrate	enc time	dec time	ren time
Balloons	0.00%	0.08%	0.31%	0.09%	0.09%	0.09%	100.2%	94.1%	101.0%
Kendo	0.00%	0.03%	0.26%	0.06%	0.05%	0.06%	99.6%	102.1%	99.0%
Newspaper_CC	0.00%	0.04%	0.01%	0.02%	-0.02%	0.02%	98.6%	100.1%	98.1%
GT_Fly	0.00%	-0.31%	-0.18%	-0.07%	-0.07%	-0.07%	100.4%	100.8%	104.5%
Poznan_Hall2	0.00%	0.05%	0.06%	0.03%	0.05%	-0.09%	98.4%	96.5%	100.9%
Poznan_Street	0.00%	-0.47%	0.01%	-0.06%	-0.05%	-0.04%	99.3%	91.0%	101.6%
Undo_Dancer	0.00%	-0.47%	-0.63%	-0.18%	-0.17%	-0.06%	100.2%	95.9%	102.4%
1024x768	0.00%	0.05%	0.19%	0.06%	0.04%	0.06%	99.5%	98.8%	99.3%
1920x1088	0.00%	-0.30%	-0.18%	-0.07%	-0.06%	-0.07%	99.6%	96.0%	102.4%
average	**0.00%**	**-0.15%**	**-0.02%**	**-0.01%**	**-0.02%**	**-0.01%**	**99.5%**	**97.2%**	**101.1%**

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Simplified NBDV (4)

❖ Complexity Analysis (CU-level) (1/2)

▪ Number of operations

• Based on the current Spec.

	NBDV		Simplified NBDV	
	CTC	BVSP and DoNBDV off	CTC (ratio)	BVSP and DoNBDV off (ratio)
Comparison	260	249	112 (43%)	101 (41%)
Multiplication	3	3	1 (33%)	1 (33%)
Addition	30	16	22 (73%)	8 (50%)

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Simplified NBDV (5)

❖ Complexity Analysis (CU-level) (2/2)

  ▪ Memory bandwidth analysis

	NBDV		Simplified NBDV	
	CTC	BVSP and DoNBDV off	CTC (ratio)	BVSP and DoNBDV off (ratio)
off-chip memory bandwidth	**44 bytes**	**40 bytes**	**24 bytes** (55%)	**20 bytes** (50%)

	• 4 Temporal Candidates;
	  10 bytes * 4 = 40 bytes
	• 4 depth pixels;
	  1 byte * 4 = 4 bytes
		• 4 Temporal Candidates;
		  10 bytes * 4 = 40 bytes
			• 2 Temporal Candidates;
			  10 bytes * 2 = 20 bytes
			• 4 depth pixels;
			  1 byte * 4 = 4 bytes
				• 2 Temporal Candidates;
				  10 bytes * 2 = 20 bytes

on-chip memory bandwidth	**50 bytes**	**50 bytes**	**20 bytes** (40%)	**20 bytes** (40%)

	• 5 Spatial Candidates;
	  10 bytes * 5 = 50 bytes
		• 5 Spatial Candidates;
		  10 bytes * 5 = 50 bytes
			• 2 Spatial Candidates;
			  10 bytes * 2 = 20 bytes
				• 2 Spatial Candidates;
				  10 bytes * 2 = 20 bytes

- Accessing motion information of temporal candidate; **off-chip memory access**
- Accessing motion information of spatial candidate; **on-chip memory access**
- Size of each motion information; **10 bytes** (("4-byte MV" + "1-byte ref_idx") * 2 (for list0 and list1))

- Accessing depth pixels for the depth-based derivation; **off-chip memory access**
- # of depth pixel to be accessed; **4 pixels**
- Size of depth pixel; **1 byte**

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Improved DV Derivation (1)

❖ At last meeting, we proposed a depth-based 2-step DV derivation (CE2)

- 1st Step: Depth based derivation
  - Find corresponding depth block by using **initial DV**
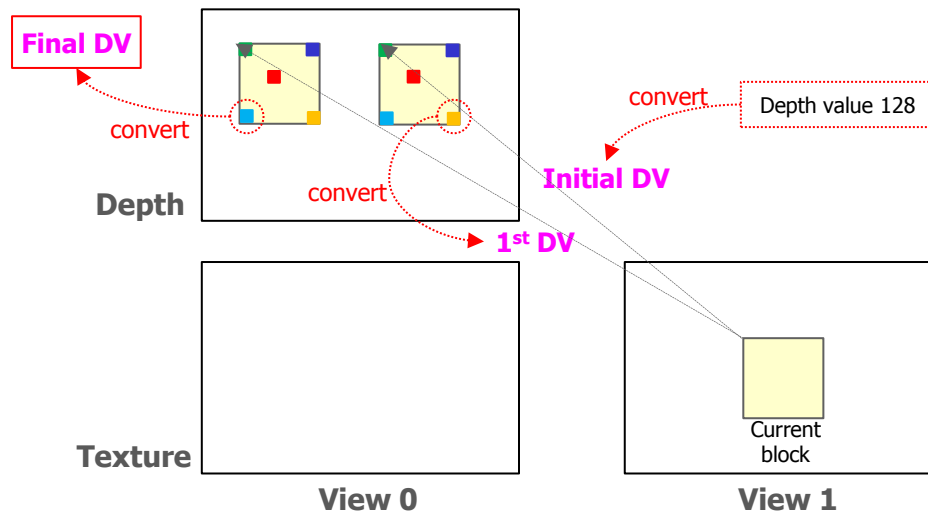 - Max. depth value ➜ **1st DV**

  set to corresponding value
  of **depth value 128**

- 2nd Step: Depth based derivation
  - Find corresponding depth block by using **1st DV**
  - Max. depth value ➜ **Final DV**

❖ However, we observed that NBDV is suitable for ARP, which was adopted at the last meeting

Improved DV Derivation (1)

❖ Therefore, we propose
- to basically use "Depth-base 2-Step DV derivation"
- to additionally use "Simplified NBDV" when the current block is coded with ARP

❖ Comparison of "Performed Process" and "Used DV"
- Derived DV is used for
  - Inter-view candidate derivation
  - BVSP
  - ARP

	HTM 7.0r1		Proposed Method	
	Inter-view	BVSP and ARP	Inter-view & BVSP	ARP
Performed Process	NBDV + DoNBDV		2-Step	2-Step + Simplified NBDV
	• DoNBDV is always needed to identify "the temporal inter-view candidate"		• NBDV is not needed to identify "the temporal inter-view candidate"	
Used DV	DoNBDV	NBDV	2-Step	Simplified NBDV

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Improved DV Derivation (2)

❖ Experimental results (**CTC**)

- Based on HTM 7.0r1
- 0.6% and 0.7% bit-saving for video 1 & video 2
- 0.2% and 0.1% bit-saving for coded and synthesized views

	video 0	video 1	video 2	video PSNR / video bitrate	video PSNR / total bitrate	synth PSNR / total bitrate	enc time	dec time	ren time
Balloons	0.0%	-0.4%	-0.3%	-0.1%	-0.1%	-0.1%	99.2%	89.4%	97.5%
Kendo	0.0%	-0.3%	-0.4%	-0.1%	-0.1%	-0.1%	100.2%	99.6%	100.6%
Newspaper_CC	0.0%	-0.6%	-0.9%	-0.3%	-0.2%	-0.1%	100.3%	97.0%	99.5%
GT_Fly	0.0%	-0.5%	-0.6%	-0.1%	-0.1%	-0.1%	99.9%	92.8%	102.0%
Poznan_Hall2	0.0%	-0.4%	-0.2%	-0.1%	-0.2%	-0.1%	100.3%	94.7%	100.5%
Poznan_Street	0.0%	-0.7%	-0.7%	-0.2%	-0.2%	-0.2%	99.8%	102.6%	99.8%
Undo_Dancer	0.0%	-1.0%	-1.9%	-0.4%	-0.4%	-0.2%	100.4%	100.4%	100.0%
1024x768	0.0%	-0.4%	-0.5%	-0.2%	-0.2%	-0.1%	99.9%	95.4%	99.2%
1920x1088	0.0%	-0.6%	-0.9%	-0.2%	-0.2%	-0.1%	100.1%	97.6%	100.6%
average	**0.0%**	**-0.6%**	**-0.7%**	**-0.2%**	**-0.2%**	**-0.1%**	**100.0%**	**96.7%**	**100.0%**

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Improved DV Derivation (3)

❖ Complexity Analysis (CU-level) (1/2)
- Number of operations
  - Based on the current Spec.

	DoNBDV		Improved DV derivation	
	CTC (Inter-view & BVSP)	CTC (ARP)	CTC (Inter-view & BVSP) (ratio)	CTC (ARP) (ratio)
Comparison	260	260	22 (8%)	123 (47%)
Multiplication	3	3	0 (0%)	1 (33%)
Addition	30	30	28 (93%)	36 (120%)

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Improved DV Derivation (4)

❖ ## Complexity Analysis (CU-level) (2/2)

▪ ### Memory bandwidth analysis

	DoNBDV		Improved DV Derivation	
	CTC (Inter-view & BVSP)	CTC (ARP)	CTC (Inter-view & BVSP) (ratio)	CTC (ARP) (ratio)
off-chip memory bandwidth	**44 bytes**	**44 bytes**	**8 bytes** (18%)	**28 bytes** (64%)

	• 4 Temporal Candidates;
	  10 bytes * 4 = 40 bytes
	• 4 depth pixels;
	  1 byte * 4 = 4 bytes
		• 4 Temporal Candidates;
		  10 bytes * 4 = 40 bytes
		• 4 depth pixels;
		  1 byte * 4 = 4 bytes
			• 8 depth pixels;
			  1 byte * 8 = 8bytes
				• 8 depth pixels;
				  1 byte * 8 = 8 bytes
				• 2 Temporal Candidates;
				  10 bytes * 2 = 20 bytes

on-chip memory bandwidth	**50 bytes**	**50 bytes**	**0 bytes** (0%)	**20 bytes** (40%)

	• 5 Spatial Candidates;
	  10 bytes * 5 = 50 bytes
		• 5 Spatial Candidates;
		  10 bytes * 5 = 50 bytes
			• N/A	• 2 Spatial Candidates;
				  10 bytes * 2 = 20 bytes

- Accessing motion information of temporal candidate; **off-chip memory access**
- Accessing motion information of spatial candidate; **on-chip memory access**
- Size of each motion information; **10 byte** (("4-byte MV" + "1-byte ref_idx") * 2 (for list0 and list1))

- Accessing depth pixels for the depth-based derivation; **off-chip memory access**
- # of depth pixel to be accessed; **4 pixels**
- Size of depth pixel; **1 byte**

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Using unavailable DV for ARP (1)

❖ In the current 3D-HEVC, when NBDV is unavailable, ARP is not performed

- However, an appropriate DV can be used to allow ARP

❖ Therefore, we propose, when NBDV is unavailable,

- to use the depth-based 2-step DV for ARP in case of CTC
- to use the DV corresponding to the depth value 128 in case of non-CTC

Using unavailable DV for ARP (2)

❖ Experimental results (**CTC**)

- ■ Based on HTM 7.0r1
- ■ 0.5% and 0.7% bit-saving for video 1 & video 2
- ■ 0.2% bit-saving for coded and synthesized views

	video 0	video 1	video 2	video PSNR / video bitrate	video PSNR / total bitrate	synth PSNR / total bitrate	enc time	dec time	ren time
Balloons	0.0%	-0.5%	-0.3%	-0.2%	-0.1%	-0.1%	99.9%	90.6%	98.0%
Kendo	0.0%	-0.3%	-0.5%	-0.2%	-0.1%	-0.1%	100.1%	93.0%	98.8%
Newspaper_CC	0.0%	-0.6%	-0.9%	-0.3%	-0.2%	-0.2%	101.0%	94.2%	98.9%
GT_Fly	0.0%	-0.5%	-0.6%	-0.1%	-0.2%	-0.1%	99.4%	97.1%	100.8%
Poznan_Hall2	0.0%	-0.2%	-0.2%	0.0%	-0.1%	0.0%	100.3%	95.9%	100.7%
Poznan_Street	0.0%	-0.7%	-0.7%	-0.2%	-0.2%	-0.2%	99.8%	105.0%	101.3%
Undo_Dancer	0.0%	-1.0%	-1.9%	-0.4%	-0.4%	-0.3%	99.7%	100.2%	99.7%
1024x768	0.0%	-0.5%	-0.6%	-0.2%	-0.2%	-0.1%	100.3%	92.6%	98.5%
1920x1088	0.0%	-0.6%	-0.8%	-0.2%	-0.2%	-0.2%	99.8%	99.6%	100.6%
average	**0.0%**	**-0.5%**	**-0.7%**	**-0.2%**	**-0.2%**	**-0.2%**	**100.0%**	**96.6%**	**99.7%**

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Using unavailable DV for ARP (3)

❖ Experimental results (**non-CTC; BVSP and DoNBDV off**)

- Based on HTM 7.0r1
- 0.3% and 0.4% bit-saving for video 1 and video 2
- 0.1% bit-saving for coded and synthesized views

	video 0	video 1	video 2	video PSNR / video bitrate	video PSNR / total bitrate	synth PSNR / total bitrate	enc time	dec time	ren time
Balloons	0.0%	-0.3%	-0.5%	-0.2%	-0.2%	-0.1%	99.4%	97.6%	99.0%
Kendo	0.0%	-0.4%	-0.4%	-0.2%	-0.2%	-0.2%	99.0%	98.0%	98.8%
Newspaper_CC	0.0%	-0.8%	-0.9%	-0.3%	-0.3%	-0.3%	99.5%	104.1%	100.4%
GT_Fly	0.0%	-0.3%	0.0%	-0.1%	-0.1%	0.0%	99.6%	96.9%	103.4%
Poznan_Hall2	0.0%	0.6%	-0.4%	0.1%	0.1%	0.0%	99.0%	94.9%	98.7%
Poznan_Street	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	99.2%	89.3%	100.1%
Undo_Dancer	0.0%	-0.5%	-0.9%	-0.2%	-0.2%	-0.3%	99.5%	94.6%	102.2%
1024x768	0.0%	-0.5%	-0.6%	-0.2%	-0.2%	-0.2%	99.3%	99.9%	99.4%
1920x1088	0.0%	-0.1%	-0.3%	0.0%	0.0%	-0.1%	99.3%	93.9%	101.1%
average	**0.0%**	**-0.3%**	**-0.4%**	**-0.1%**	**-0.1%**	**-0.1%**	**99.3%**	**96.5%**	**100.4%**

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Conclusions

❖ We propose 3 methods for simplifying and improving DV derivation.

- 0.2% bit-saving on coded and synthesized views
- Lower complexity compared with the current DV derivation

❖ We recommend to adopt the proposed methods into next 3D-HEVC TM.

Thanks to Qualcomm for the cross checking (JCT3V-E0279).

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