

JCT3V-D0090: AhG 10: Complexity Assessment on Adaptive Luminance Compensation and Plane Segmentation based Intra Prediction in 3D-AVC

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Outline

- Method of Complexity Assessment
- Case Studies
 - Adaptive Luminance Compensation (ALC)
 - Plane Segmentation based Intra Prediction (PSIP)
- Conclusion

Method of Complexity Assessment (1/2)

- Flowchart construction for an iteration
 - Based on the specification and test model
 - Data causality establishment
 - Major processes or key modules identification
- Major processes or key modules analysis
 - Number of operations
 - Data storage requirement
 - Data transfer rate
- Analyzes at different data granularities

Method of Complexity Assessment (2/2)

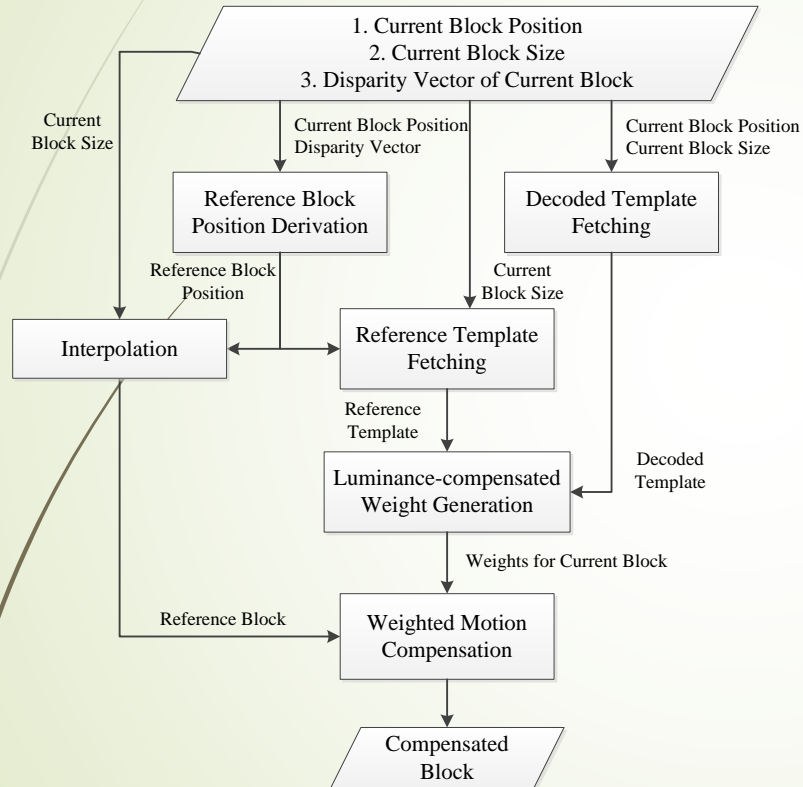
- Number of operations
 - Mathematical expressions
 - Basic operations
 - Addition, multiplication, division, etc.
- Data storage requirement
 - Analyzed by flowchart and the different data granularity
 - Input and output data storage
 - Intermediate data storage
- Data transfer rate
 - Analyzed by flowchart and the data granularity
 - Amount of Input and output data with one data granularity

Case Study on ALC (1/9)

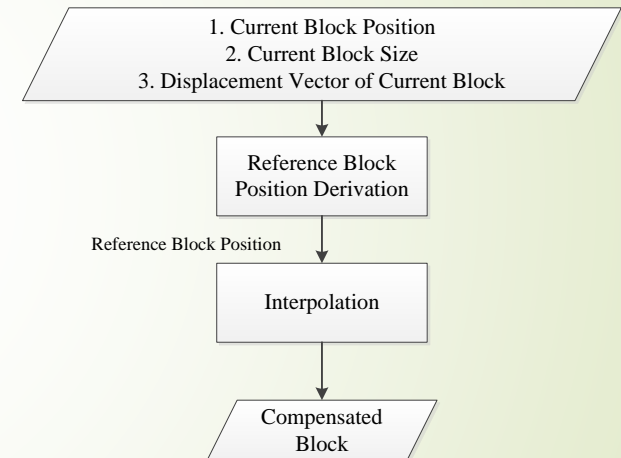
- Decoder complexity analysis
- Data granularity: one macroblock (MB)
- ALC vs. DCP/MCP
 - Number of operations
 - Data storage requirement
 - Data transfer rate
 - Coding performance → turn off ALC vs. 3DV-ATMv7.0
 - Encoding/Decoding time → turn off ALC vs. 3DV-ATMv7.0

Case Study on ALC (2/9)

Flowchart of ALC



Flowchart of DCP/MCP



Case Study on ALC (3/9)

- Major process of ALC
 - Luminance-compensated weight generation
 - Interpolation
 - Weighted motion compensation
- Major process of DCP/MCP
 - Interpolation

E.g. Ref_Dec calculation in ALC:

1+(4*psy+4*psx) addition,

(4*psy+4*psx) subtraction,

(4*psy+4*psx) comparison

$$\text{Ref_Dec} = 1 + \sum_{k,m=[1..4,1..psy]} \text{LD}[k,m] \times \begin{cases} 1, & |\text{LD}[k,m] - \text{LR}[k,m]| < TH \\ 0, & \text{otherwise} \end{cases} +$$

$$\sum_{k,m=[1..psx,1..4]} \text{UD}[k,m] \times \begin{cases} 1, & |\text{UD}[k,m] - \text{UR}[k,m]| < TH \\ 0, & \text{otherwise} \end{cases}$$

Case Study on ALC (4/9)

Data storage requirement for one MB (bits)		
	ALC	DCP/MCP
Displacement vector	$(16/M) \times (16/N) \times 32$	$(16/M) \times (16/N) \times 32$
Reference block with extend taps	$(M+5) \times (N+5) \times 8$	$(M+5) \times (N+5) \times 8$
Reference and decoded template	$((4 \times 16) + (16 \times 4)) \times 2 \times 8$	N/A
Compensated block	$16 \times 16 \times 8$	$16 \times 16 \times 8$

M and N stand for the width and height of the mb_type
 Bits of one pixel is considered as 8 bits
 One component of disparity vector is 16 bits

Case Study on ALC (5/9)

Data transfer rate for one MB (bits/MB)		
	ALC	DCP/MCP
Displacement vector	$(16/M) \times (16/N) \times 32$	$(16/M) \times (16/N) \times 32$
Reference block with extend taps	$(M+5) \times (N+5) \times (16/M) \times (16/N) \times 8$	$(M+5) \times (N+5) \times (16/M) \times (16/N) \times 8$
Reference and decoded template	$((4 \times 16) + (16 \times 4)) \times 2 \times 8$	N/A
Compensated block	$16 \times 16 \times 8$	$16 \times 16 \times 8$

M and N stand for the width and height of the mb_type
 Bits of one pixel is considered as 8 bits
 One component of disparity vector is 16 bits

Case Study on ALC (6/9)

10

➤ Number of operations

Number of operations						
		ALC			DCP/MCP	
mb_type		Mul.	Constant Mul	Add./ Sub./ Comp.	Constant Mul.	Add./ Sub./ Comp.
P_L0_16x16		257	2048	5383	2048	3585
P_L0_L0_16x8		258	2048	6158	2048	3586
P_L0_L0_8x16		258	2048	6158	2048	3586
P_Skip		257	2048	5383	2048	3585
P_8x8, P_8x8ref0	P_L0_8x8	260	2048	6940	2048	3588
	P_L0_8x4	264	2048	6968	2048	3592
	P_L0_4x8	264	2048	6968	2048	3592
	P_L0_4x4	272	2048	10096	2048	3600

Constant Mul.: the multiplication with constant

Case Study on ALC (7/9)

11

➤ Data storage requirement

Data storage requirement (bits)			
mb_type	ALC	DCP/MCP	Ratio (Total)
P_LO_16x16	7656	5608	136.52%
P_LO_LO_16x8	6344	4296	147.67%
P_LO_LO_8x16	6344	4296	147.67%
P_Skip	7656	5608	136.52%
P_8x8, P_8x8ref0	P_LO_8x8	3528	158.05%
	P_LO_8x4	3240	163.21%
	P_LO_4x8	3240	163.21%
	P_LO_4x4	3208	163.84%

Case Study on ALC (8/9)

► Data transfer rate

Data transfer rate (bits/MB)				
mb_type		ALC	DCP/MCP	Ratio (Total)
P_L0_16x16		7624	5608	135.95%
P_L0_L0_16x8		8464	6480	130.62%
P_L0_L0_8x16		8464	6480	130.62%
P_Skip		7624	5608	135.95%
P_8x8, P_8x8ref0	P_L0_8x8	9504	7584	125.32%
	P_L0_8x4	11584	9792	118.30%
	P_L0_4x8	11584	9792	118.30%
	P_L0_4x4	14464	12928	111.88%

Case Study on ALC (9/9)

13

- Coding performance, encoding/decoding time comparison
 - Significant coding loss when ALC is OFF.

	Texture Coding		Total (Coded PSNR)		Total (Synthesized PSNR)		Complexity estimate (ratio to anchor)		
	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	Encoder Time, %	Decoder Time, %	Rendering Time, %
S01	2.05	-0.07	1.94	-0.06	1.10	-0.04	98.11	99.20	99.60
S02	0.36	-0.01	0.40	-0.01	-0.30	0.01	98.47	98.14	97.91
S03	0.33	-0.01	0.32	-0.01	0.10	0.00	98.19	99.43	100.54
S04	0.02	0.00	0.02	0.00	-0.02	0.00	98.11	99.63	100.24
S05	3.32	-0.16	2.97	-0.13	1.97	-0.08	97.99	99.91	101.84
S06	3.54	-0.17	3.36	-0.16	2.04	-0.09	98.20	100.07	102.53
S08	2.80	-0.12	2.72	-0.11	1.40	-0.05	97.93	98.85	100.13
Average	1.78	-0.08	1.68	-0.07	0.90	-0.04	98.14	99.32	100.40

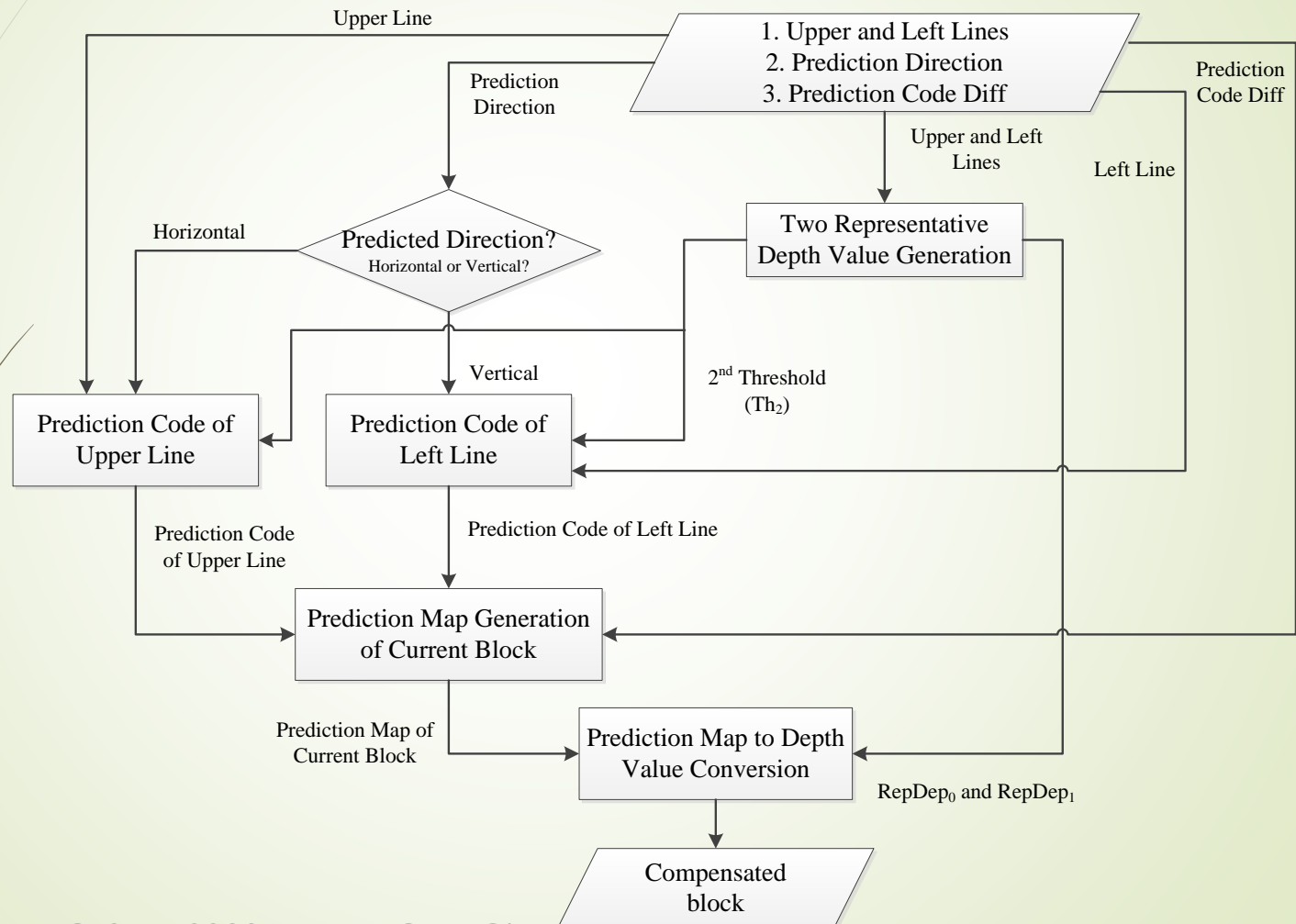
Anchor: 3DV-ATMv7.0

Tested: 3DV-ATMv7.0 with ALC OFF

Case Study on PSIP(1/9)

- Decoder complexity analysis
- Data granularity: one MB
- PSIP vs. DC intra prediction
 - Number of operations
 - Data storage requirement
 - Data transfer rate
 - Coding performance → turn off PSIP vs. 3DV-ATMv7.0
 - Encoding/Decoding time → turn off PSIP vs. 3DV-ATMv7.0

Case Study on PSIP(2/9)



Case Study on PSIP(3/9)

- Major processes of PSIP
 - Two representation depth value generation
 - Predicted code of neighboring line
 - Prediction code generation of current block and prediction map to depth conversion
- Major processes of DC intra prediction
 - Average filter

E.g. Prediction code generation
2 additions, % is not considered as an operation

$$PredictionCode[n] = (PredictionCode[n-1] + PredictionCodeDiff[n] + 2N) \% 2N$$

Case Study on PSIP(4/9)

Data storage requirement for one MB (bits)		
	PSIP	DC intra-prediction
Upper and left lines	$(16+16) \times 8$	$(16+16) \times 8$
Prediction code difference	$N \times ((16/N) \times (16/N)) \times \log_2(2N)$	N/A
Table for prediction map	$2N \times M$	N/A
Compensated block	$16 \times 16 \times 8$	$16 \times 16 \times 8$

N stand for both width and height of the mb_type
 Bits of one pixel is considered as 8 bits

Case Study on PSIP(5/9)

Data transfer rate for one MB (bits/MB)		
	PSIP	DC intra-prediction
Upper and left lines	$(16+16) \times 8$	$(16+16) \times 8$
Prediction code difference	$N \times ((16/N) \times (16/N)) \times \log_2(2N)$	N/A
Compensated block	$16 \times 16 \times 8$	$16 \times 16 \times 8$

N stand for both width and height of the mb_type
Bits of one pixel is considered as 8 bits

Case Study on PSIP(6/9)

Number of operations			
	PSIP		DC intra-prediction
mb_type	Div	Add./Comp.	Add.
Intra_16x16	2	413	32
Intra_8x8	8	564	64
Intra_4x4	32	848	96

Case Study on PSIP(7/9)

Data storage requirement (bits)			
mb_type	PSIP	DC intra-prediction	Ratio (Total)
Intra_16x16	2896	2304	125.69%
Intra_8x8	2560	2304	111.11%
Intra_4x4	2528	2304	109.72%

Case Study on PSIP(8/9)

Data transfer rate (bits/MB)			
mb_type	PSIP	DC intra-prediction	Ratio (Total)
Intra_16x16	2384	2304	103.47%
Intra_8x8	2432	2304	105.56%
Intra_4x4	2496	2304	108.33%

Case Study on PSIP(9/9)

22

- Coding performance, encoding/decoding time comparison
 - Comparative coding performance; however, the PSIP will provide better visual quality on depth map
 - The decoding time reduction of PSIP OFF due to the CABAC process.

	Texture Coding		Depth Coding		Total (Coded PSNR)		Total (Synthesized PSNR)		Complexity estimate (ratio to anchor)		
	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	Encoder Time, %	Decoder Time, %	Rendering Time, %
S01	0.13	-0.01	-0.17	0.00	0.09	0.00	0.85	-0.03	99.49	91.92	96.60
S02	0.08	0.00	-0.26	0.02	0.01	0.00	0.09	0.00	100.28	90.68	97.06
S03	0.08	0.00	0.06	-0.01	-0.02	0.00	0.70	-0.02	99.93	93.54	101.69
S04	0.04	0.00	-1.09	0.07	-0.06	0.00	0.08	0.00	99.87	94.39	100.31
S05	0.08	0.00	-0.52	0.02	0.01	0.00	0.17	-0.01	99.69	93.17	98.93
S06	0.02	0.00	-0.80	0.04	-0.07	0.00	0.02	0.00	100.00	93.50	101.62
S08	0.02	0.00	0.44	-0.02	-0.07	0.00	0.17	0.00	99.71	92.14	99.25
Average	0.06	0.00	-0.34	0.02	-0.02	0.00	0.30	-0.01	99.85	92.76	99.35

Anchor: 3DV-ATMv7.0

Tested: 3DV-ATMv7.0 with PSIP OFF

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2013/4/23

Conclusion

- ALC vs. DCP/MCP
 - ALC needs more number of operations, larger data storage, and higher data transfer rate
 - Coding loss is significant when ALC is OFF
- PSIP vs. DC intra prediction
 - Quality of depth data is slightly improved with slightly operations increasing
 - Comparative coding performance when PSIP is OFF
- With the analysis results, the coding tool can be evaluated more objectively.
- This proposal recommends that this analysis method would be took into consideration for the coding tool development.

Thanks for your attention!