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

National Cheng Kung University
Chun-Fu Chen, Gwo Giun (Chris) Lee

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)

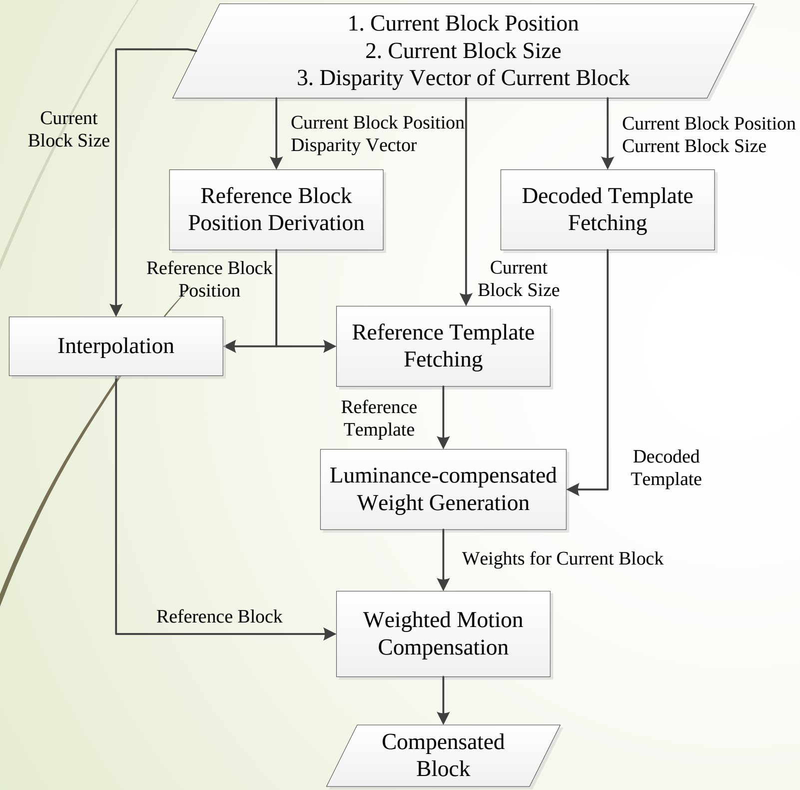
- Number of operations
  - Mathematical expressions
  - Basic operations
    - Addition, multiplication, division, etc.
- Data storage requirement
  - Analyzed by flowchart and the different data granularity
  - Input and output data storage
  - Intermediate data storage
- Data transfer rate
  - Analyzed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

Case Study on ALC (1/9)

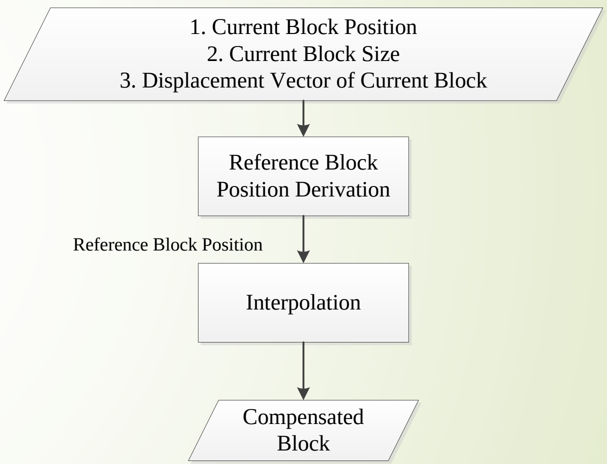
- Decoder complexity analysis
- Data granularity: one marcoblock (MB)
- ALC vs. DCP/MCP
  - Number of operations
  - Data storage requirement
  - Data transfer rate
  - Coding performance → turn off ALC vs. 3DV-ATMv7.0
  - Encoding/Decoding time → turn off ALC vs. 3DV-ATMv7.0

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

$$\mathrm{Ref\_Dec} = 1 + \sum_{k,m=[1..4,1..psy]} \mathrm{LD}[k,m] \times \begin{cases} 1, \left|\mathrm{LD}[k,m] - \mathrm{LR}[k,m]\right| < TH \\ 0, otherwise \end{cases} + \sum_{k,m=[1..psx,1..4]} \mathrm{UD}[k,m] \times \begin{cases} 1, \left|\mathrm{UD}[k,m] - \mathrm{UR}[k,m]\right| < TH \\ 0, otherwise \end{cases}$$

Case Study on ALC (4/9)

Data storage requirement for one MB (bits)		
	ALC	DCP/MCP
Displacement vector	(16/M)x(16/N)x32	(16/M)x(16/N)x32
Reference block with extend taps	(M+5)x(N+5)x8	(M+5)x(N+5)x8
Reference and decoded template	((4x16)+(16x4))x2x8	N/A
Compensated block	16x16x8	16x16x8

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)x(16/N)x32	(16/M)x(16/N)x32
Reference block with extend taps	(M+5)x(N+5) x(16/M)x(16/N)x8	(M+5)x(N+5) x(16/M)x(16/N)x8
Reference and decoded template	((4x16)+(16x4))x2x8	N/A
Compensated block	16x16x8	16x16x8

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)

- 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)

- Data storage requirement

Data storage requirement (bits)			
mb_type		ALC	DCP/MCP
P_L0_16x16		7656	5608
P_L0_L0_16x8		6344	4296
P_L0_L0_8x16		6344	4296
P_Skip		7656	5608
P_8x8, P_8x8ref0	P_L0_8x8	5576	3528
	P_L0_8x4	5288	3240
	P_L0_4x8	5288	3240
	P_L0_4x4	5256	3208

Case Study on ALC (8/9)

- Data transfer rate

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

Case Study on ALC (9/9)

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

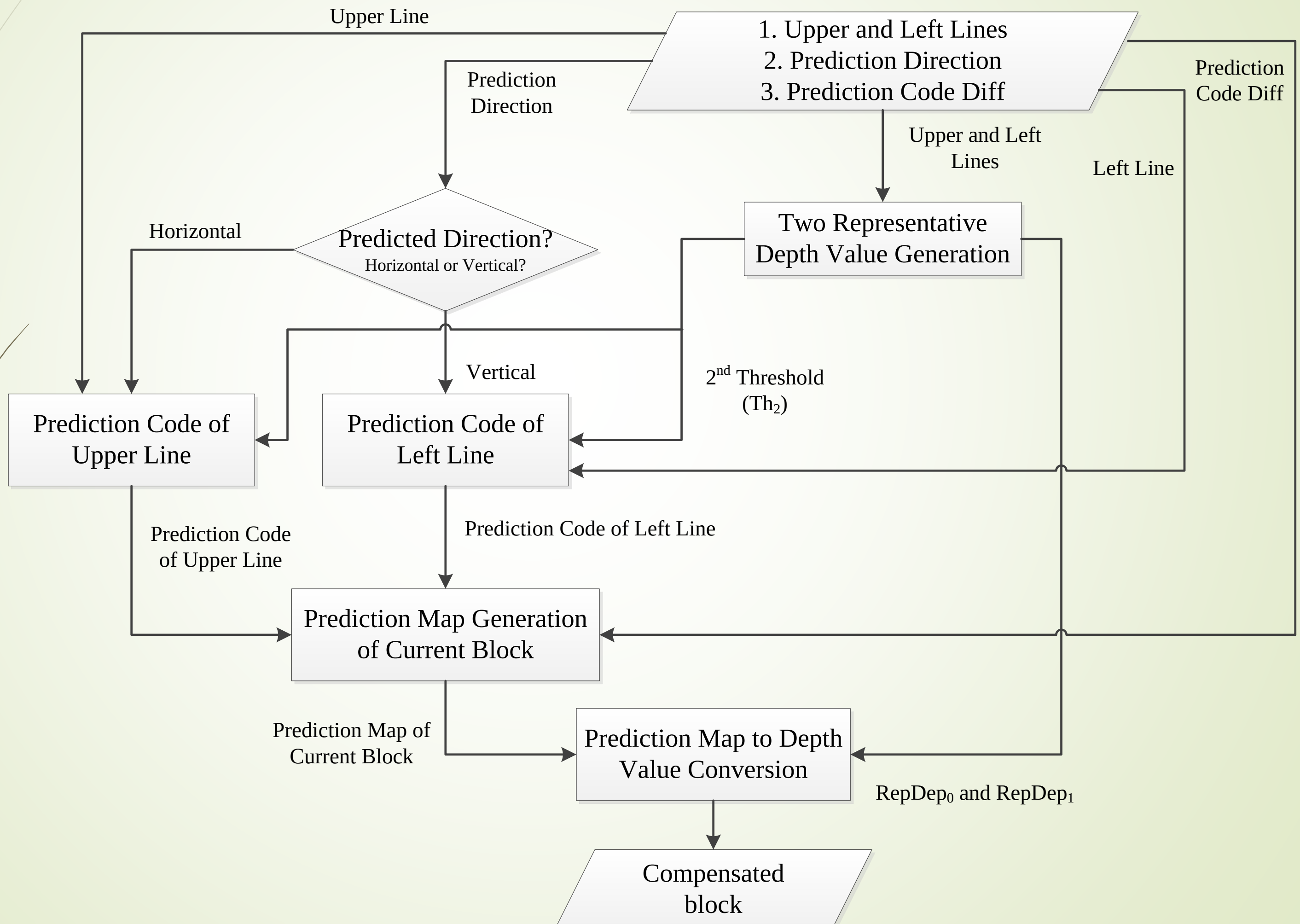
	Texture Coding		Total (Coded PSNR)		Total (Synthesized PSNR)		Complexity estimate (ratio to anchor)		
	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	dBR, %	dPSNR, dB	Encoder Time, %	Decoder Time, %	Rendering Time, %
S01	2.05	-0.07	1.94	-0.06	1.10	-0.04	98.11	99.20	99.60
S02	0.36	-0.01	0.40	-0.01	-0.30	0.01	98.47	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

$$\Pr edictionCode[n] = \left(\Pr edcitionCode[n-1] + \Pr edictionCodeDiff[n] + 2N\right)\%2N$$

Case Study on PSIP(4/9)

Data storage requirement for one MB (bits)		
	PSIP	DC intra-prediction
Upper and left lines	(16+16)x8	(16+16)x8
Prediction code difference	Nx((16/N)x(16/N))x log2(2N)	N/A
Table for prediction map	2NxM	N/A
Compensated block	16x16x8	16x16x8

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)x8	(16+16)x8
Prediction code difference	Nx((16/N)x(16/N))x log2(2N)	N/A
Compensated block	16x16x8	16x16x8

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
Intra_16x16	2896	2304
Intra_8x8	2560	2304
Intra_4x4	2528	2304

Case Study on PSIP(8/9)

Data transfer rate (bits/MB)		
mb_type	PSIP	DC intra-prediction
Intra_16x16	2384	2304
Intra_8x8	2432	2304
Intra_4x4	2496	2304

Case Study on PSIP(9/9)

- 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

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!