RDO Cost Modeling for Low-Complexity HEVC Intra Coding

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1. INTRODUCTION

❖ Problem

- High efficiency video coding (HEVC) is the newest international standard for video compression
- Improved coding performance (50% higher than H.264)
- This improvement comes at the expense of high computational complexity and coding time
- With intra coding, HEVC employs 35 modes while H.264 considers a maximum of 9

❖ Prior Art

- Select the *N* modes with the lowest RMD costs and run the RDO only for these modes (HM standard implementation)

$$Cost_{RMD} = SATD_{luma} + \lambda_{pred} \times R_p$$

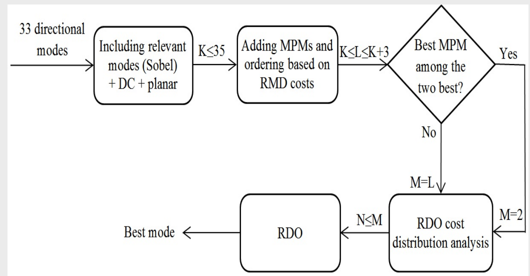
- Use neighboring blocks' modes as candidates for the best mode of the current block [Gao2015]
- Use the content of the block, like the dominant directions (edges), to specify the best intra mode [Park2015]

2. PROPOSED APPROACH

❖ Binary Classification

- Classify the modes into *promising* and *non-promising* modes
- Exclude *non-promising* prediction modes from further RDO processing by applying a Gaussian model for the RDO cost
- The highly complex RDO cost computation is performed only for the *promising* modes

$$Cost_{RDO} = (SSE_{luma} + \omega_{chroma} \times SSE_{chroma}) + \lambda_{Mode} \times R_{Mode}$$



3. DESCRIPTION OF THE APPROACH

❖ Including Relevant Angular Modes

- Include only some relevant angular modes using a low-complexity edge detector

❖ Rough Most Probable Modes Examination

- Eliminate some modes when it is clear that the current block follows a similar prediction pattern as the neighboring blocks

$$m_{mpmBest} = \arg\min_{m \in MPMs} Cost_{RMD}$$

❖ Statistical RDO Cost Modeling Based on RMD Cost

- $Cost_{RDO}$ of the blocks having specific $Cost_{RMD}$ values, fit some well-known probability distributions well
- The normal distribution provides an accurate fit to the RDO cost histogram
- Set of selected candidates, before applying RDO cost distribution analysis

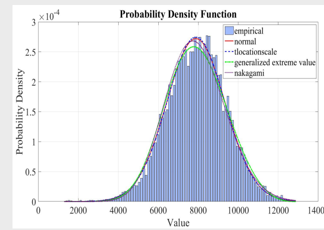
$$\psi = \{DC + Planar + Selected\ modes\ based\ on\ edge\ detection + MPMs\} = \{m_1, m_2, \ldots m_M\}$$

- Set of *promising* modes called *P* with *N* members

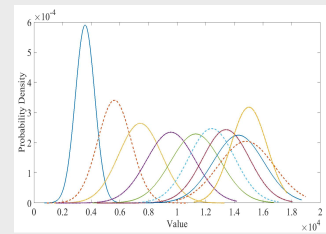
$$P \subseteq \psi \ and \ N \le M$$

- Compare the normal distributions of modes (X and Y) to eliminate the *non-promising* ones
- The criteria is P(X<Y) or P(W<0) while W=X-Y is a normal distribution with following mean and variance

$$\mu_W = \mu_X - \mu_Y \qquad \sigma_W^2 = \sigma_X^2 + \sigma_Y^2$$



RDO cost distribution for one bin of $Cost_{RMD}$



RDO cost distributions for different bins of $Cost_{RMD}$

4. EXPERIMENTAL RESULTS

- Implementation in the HEVC test model HM15.0
- *All-intra* configuration, first 100 frames

Table I. Experimental results for various video sequences compared to HM 15.0

		Proposed Method		[Gao 2015]		[Park 2015]	
Class	Video Sequences	TR(%)	BD-RATE(%)	TR(%)	BD-RATE(%)	TR(%)	BD-RATE(%)
A	Traffic	-42.3	1.21	-27.3	0.9	-	-
	PeopleOnStreet	-42.7	1.44	-24.7	0.9	-	-
B	Cactus	-42.9	1.30	-24.2	1.0	-31.5	3.06
	Kimono	-44.4	1.14	-24.1	1.3	-29.02	2.02
	ParkScene	-41.6	0.79	-26.1	0.7	-25.45	2.38
	BasketballDrive	-44.3	2.05	-	-	-	-
	BQTerrace	-42.5	0.86	-	-	-24.1	2.99
C	BQMall	-42.1	1.21	-34.2	0.9	-29.01	2.06
	PartyScene	-37.7	1.07	-27.3	0.7	-24.41	3.24
	RaceHorsesC	-39.4	0.73	-	-	-24.38	3.23
	BasketballDrill	-42.1	0.77	-28.6	1.2	-30.57	3.24
D	RaceHorses	-40.0	1.14	-29.3	1.0	-20.91	2.11
	BasketballPass	-42.1	1.62	-33.5	1.2	-24.66	2.35
	BlowingBubbles	-39.0	0.98	-	-	-26.84	3.28
	BQSquare	-38.6	1.48	-26.7	1.1	-28.32	2.39
E	Vidyo1	-43.1	1.72	-	-	-	-
	Vidyo3	-42.9	1.33	-24.8	0.9	-	-
	Vidyo4	-43.4	1.50	-	-	-	-
Average		-41.8	1.24	-27.6	1.0	-26.6	2.70

[Gao2015] L.Gao, S. Dong, W. Wang, R. Wang, W. Gao, "Fast Intra Mode Decision Algorithm Based on Refinement in HEVC", *ISCAS 2015.*

[Park2015] M. Park and J. Jeong, "Fast HEVC Intra Prediction Algorithm with Enhanced Intra Mode Grouping Based on Edge Detection in Transform Domain", *Journal of Advances in Computer Networks, June 2015.*