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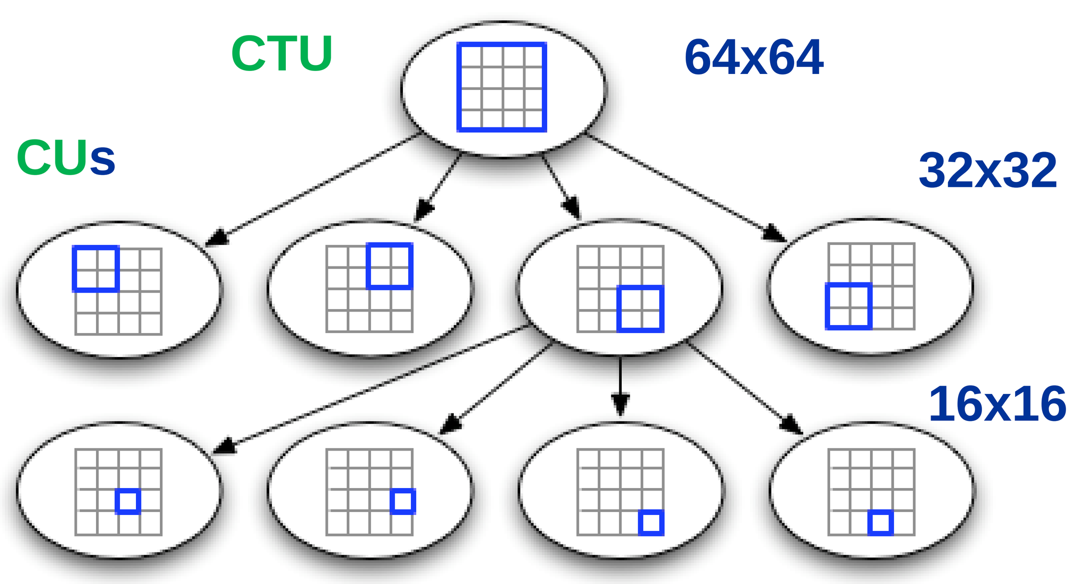
A HIGHLY PARALLEL CODING UNIT SIZE SELECTION FOR HEVC

Liron Anavi, Avi Giterman, Maya Fainshtein, Vladi Solomon, and Yair Moshe

Signal and Image Processing Laboratory (SIPL)
Andrew and Erna Viterbi Faculty of Electrical Engineering, Technion – Israel Institute of Technology

Introduction

- The High Efficiency Video Coding (HEVC) provides a substantial improvement in coding efficiency over previous standards
- HEVC employs a quad-tree based image partitioning
  - Each frame is divided into coding tree units (**CTU**s, analogous to macroblocks in previous standards)
  - Each CTU can be recursively further divided into four smaller quadratic blocks called coding units (**CU**s)
    - From up to 64x64 down to 8x8



- **Problem:** HEVC encoding incurs a high computational complexity
- **Possible solution:** Use a graphics processing unit (GPU) for acceleration
  - GPU is a highly parallel, powerful, and cost-effective processing unit, that is very common nowadays

Previous Works

- Most previous works on HEVC parallelization offload only motion estimation to the GPU
  - Further acceleration is required
  - CU size selection becomes a major bottleneck
- Most fast CU size selection algorithms use data dependency between neighboring CUs

- **A new problem:** These dependencies limit GPU parallelization capability

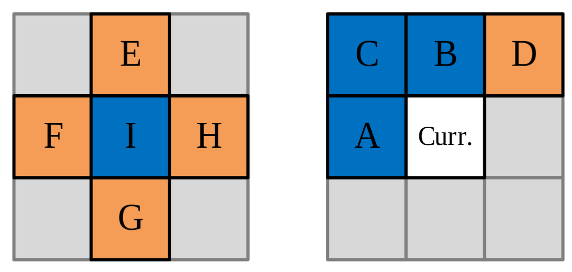
Major Contribution

- **A fast CU size selection method** that allows utilization of the **high parallel processing** capability of many-core processors, such as a GPU
  - **Does not depend on any data from other CUs in the same frame**

Serial CU Size Selection

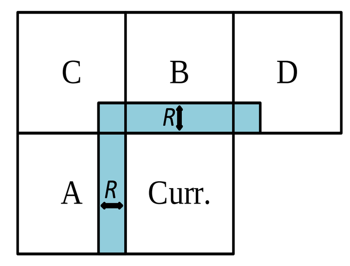
(Fan et al., 2014)

- Depth of search for the encoded CTU is determined by similarity to adjacent CTUs
- Adjacent CTUs are divided into 2 groups: $\alpha = \{A, B, C, I\}, \beta = \{D, E, F, H, G\}$



Frame N-1 Current Frame N

- Depths are checked in neighboring CTUs only in CUs that are in a small strip of size R around the CTU being evaluated

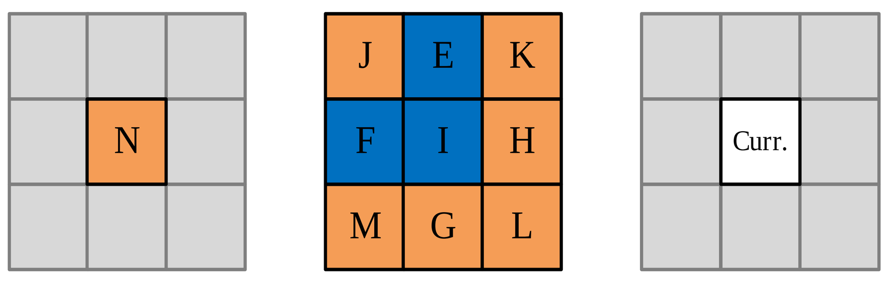


- Number of depths adopted in the strip determine a "similarity level"
- The "similarity level" determines the number of depths checked for the encoded CTU

Similarity level	Depths checked	Group β used?
low	3	no
medium-low	2 or 3	no
medium-high	1 or 2 or 3	yes
high	1 or 2	yes

Proposed CU Size Selection

- A parallel scheme based on the serial scheme described above
- Does not depend on any data from other CUs in the same frame
  - Allows high parallelism at the CTU level
- A change to groups α and β: $\alpha = \{E, F, I, I\}, \beta = \{G, H, J, K, M, N\}$



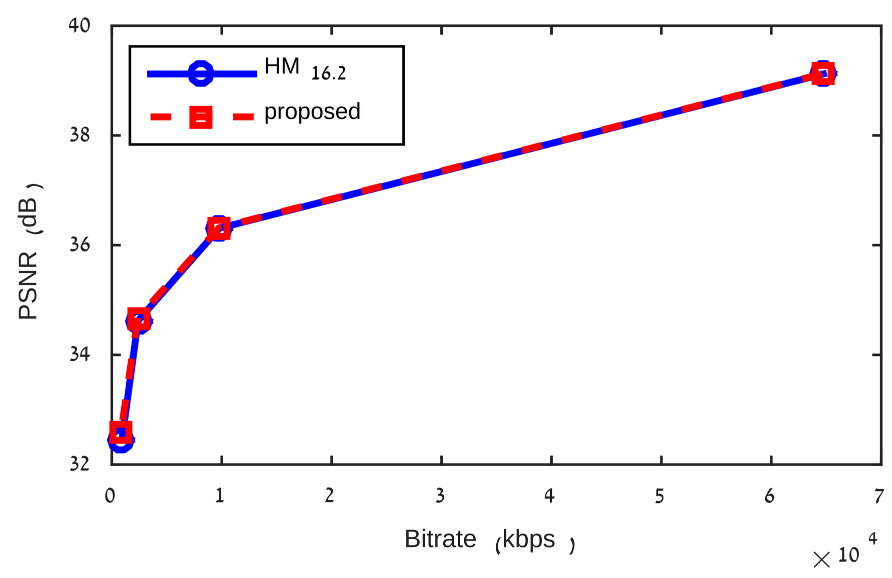
Frame N-2 Frame N-1 Current frame N

- Using only data from previous frames decreases correlation with neighboring CTUs
- Compensate for the decrease in CTU correlation by adding information from more CTUs - J, K, M, L, N
- Double weight is given to the collocated CTU I due to its highest correlation with the encoded CTU
- Same "similarity level" classification as described above
  - But now higher likelihood for high or medium-high similarity level → less depths checked

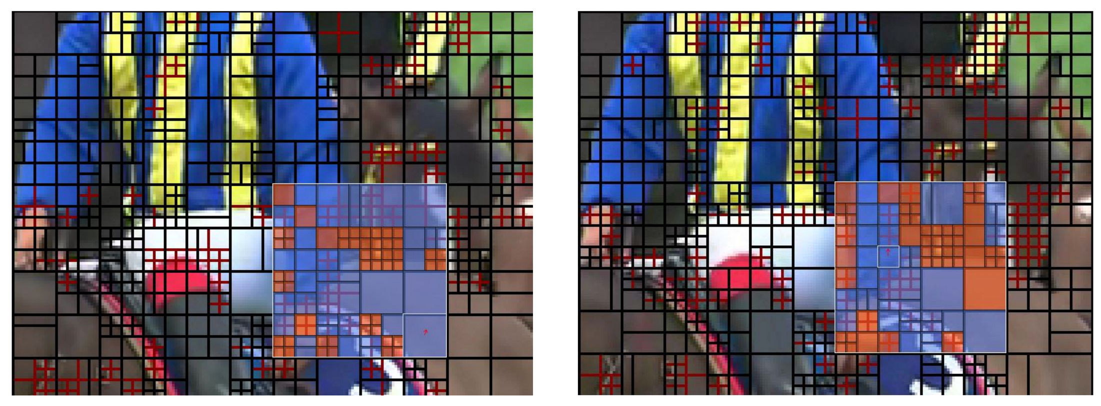
Results

Class	Sequence	(Fan et al., 2014) BD-rate [%]	(Fan et al., 2014) ΔT [%]	proposed BD-rate [%]	proposed ΔT [%]
B	BQTerrace	0.63	-41.70	3.31	-66.14
C	BasketballDrill	1.37	-38.19	0.80	-61.30
	BQMall	1.00	-38.31	1.95	-59.08
	PartyScene	0.16	-32.27	1.18	-56.41
	RaceHorses	0.50	-30.88	0.59	-55.36
D	BasketballPass	0.52	-34.74	2.45	-52.83
	BQSquare	-0.10	-27.63	2.03	-54.30
	BlowingBubbles	0.36	-25.29	1.59	-54.54
	RaceHorses	0.41	-24.26	0.98	-52.76
Average		**0.54**	**-32.58**	**1.65**	**-56.99**

Results of the proposed CU size selection method compared with (Fan et al., 2014). For each method, change in coding performance in BD-rate (Bjontegaard, 2001), and change in serial coding time ΔT, are given compared to the HM16.2 reference software. Results are measured on sequences recommended by the JCT-VC HEVC committee in class B (1920x1080), C (832×480) and D (416×240).



Rate-distortion curves of the sequence BQTerrace



Proposed method HM16.2 reference software

CU size selection of the proposed method vs. the HM16.2 reference software for the sequence RaceHorses, frame #224. Black lines denote CU partitioning and red lines denote TU partitioning. For one CTU in the frame, I CUs are marked in orange and P CUs are marked in blue. Partitioning results of both techniques are only partly similar but both adapt to image texture.

Conclusions

- A fast, highly parallel CU size selection method for HEVC
- Suitable for implementation on a many-core processor, such as a GPU
- Parallelism is achieved by removing dependencies in the same frame
- The proposed method achieves comparable coding efficiency and running times compared with counterpart serial methods that limit parallelism, even when executed in a serial manner

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