Constrain the Docile CTUs: an In-Frame Complexity Allocator for HEVC Intra Encoder

A. Mercat[*], F. Arrestier*, W. Hamidouche[*], M. Pelcat[*], D. Menard*

[*] IETR, INSA Rennes

I. Motivations

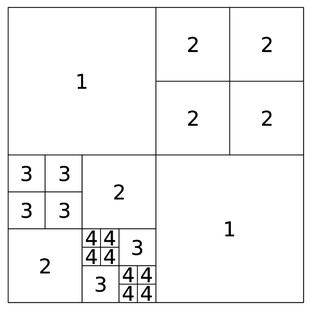
- High Efficiency Video Coding (HEVC): 40% bitrate savings when compared to the widespread H.264/AVC standard.
- Most frequent approach to reduce the complexity: reduce the optimize coding-tree search.

Contribution: method to efficiently allocate the computational complexity among CTU in a Intra encoded frame: "Constrain the Docile CTUs" (CDC).

II. Correlation between a CUTs partitioning depths and its RD-Cost

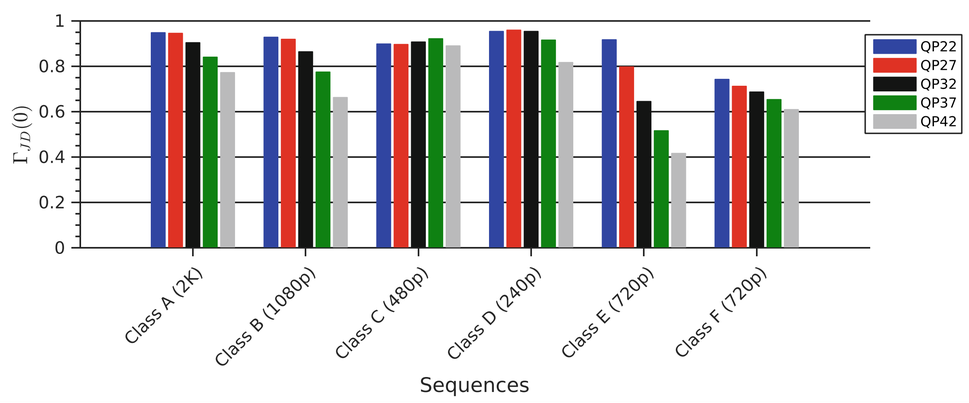
- Depths metric: quantify the partitioning depths of each CTU

$$D_{p,x,y} = \sum_{x \in [1, N_{p,x,y}]} d_x$$



➢ High correlation between the RD-Cost and the depth metric.

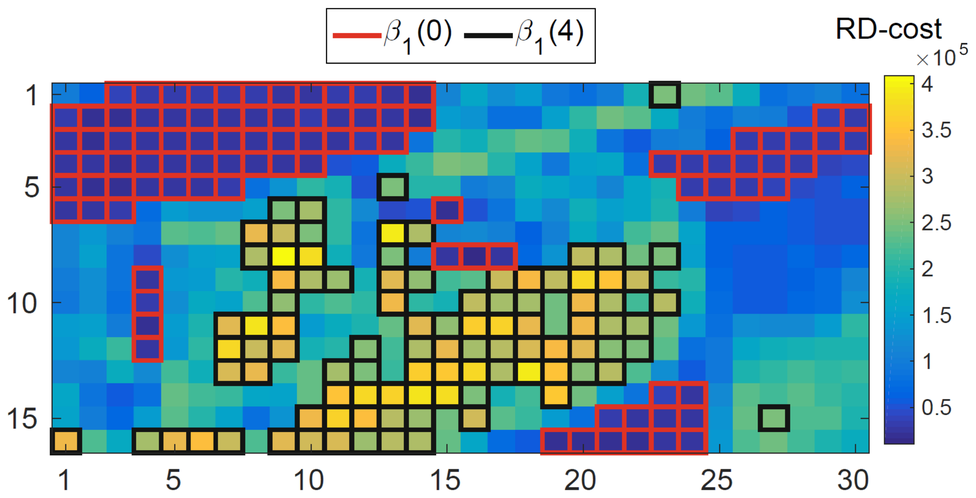
❑ **Correlation coefficient between the CTU depth metric and the RD-Cost**



III. Impacts of a CTU constraint on the RD-Cost

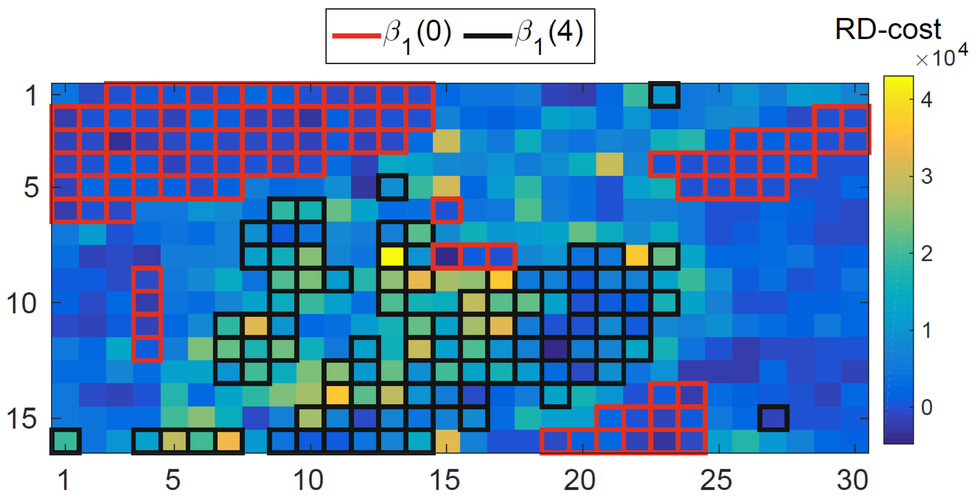
❑ **Absolute RD-cost per CTU of the first frame of BQTerrace(1080p)**

- Red blocks: the 20% of the CTUs with the lowest RD-Costs.
- Black blocks: the 20% of the CTU with the highest RD-Costs.



❑ **Relative RD-cost increase per CTU under constraint of the first frame of BQTerrace(1080p)**

- The constraint: remove the last depth of the quad-tree.



➢ CTUs with lowest RD-Cost have less increase of bit rates and/or distortion than CTUs with high RD-cost when constrained.

IV. Temporal RD-Cost stability

❑ **Average correlation coefficient of CTU RD-Costs of consecutive frames**

	QP22	QP27	QP32	QP37	QP42	**Av.**
Class A	0.991	0.989	0.987	0.985	0.983	**0.987**
Class B	0.988	0.987	0.986	0.985	0.985	**0.986**
Class C	0.986	0.986	0.986	0.985	0.985	**0.986**
Class D	0.985	0.985	0.985	0.985	0.985	**0.985**
Class E	0.986	0.986	0.986	0.986	0.986	**0.986**
Class F	0.971	0.959	0.958	0.958	0.960	**0.961**
Average	**0.985**	**0.982**	**0.981**	**0.981**	**0.981**	**0.982**

- High correlation between RD-Cost on consecutive frames of a video sequence.

➢ Use the RD-Cost of the previous frame to predict the RD-Cost of the current one.

V. The CDC Complexity Allocator

❑ **Proposed in frame complexity allocator: Constrain the Docile CTUs (CDC)**

- When CTUs have to be constrained, apply the constraint on CTUs with the lowest RD-Costs of the previous frame.
- Can be adapted to different CTU complexity reduction techniques.

➢ "Constrain the Docile CTUs": consists of reducing the encoding effort for the CTUs that lend themselves the most to encoding.

VI. Experimental Results

➢ CDC allocator evaluation: BD-rate between the CDC and four methods of allocating when the constraint is to remove the last depth level in the RDO process:

- **Upper**: the first CTUs in the raster scan order of the frame are constrained.
- **Lower**: the last CTUs in the raster scan order of the frame are constrained.
- **Tick**: every CTU out a percentage is constrained.
- **Inverse**: the exact inverse of our allocator method, i.e. the CTUs with the highest RD-Cost in the previous frame are constrained.

❑ **BD-rate between our allocator (CDC) and four others (in %)**

	Upper			Lower			Tick			Inverse		
Class	30%	50%	70%	30%	50%	70%	30%	50%	70%	30%	50%	70%
Class A	0.72	1.06	1.13	0.57	0.99	0.98	1.03	1.17	1.15	1.88	2.16	1.74
Class B	0.61	0.92	0.82	1.02	1.23	1.23	1.06	1.21	1.24	1.98	2.23	1.86
Class C	0.83	1.25	1.32	2.03	2.48	2.52	1.93	2.13	2.25	3.33	3.75	3.20
Class D	1.19	2.18	2.34	2.12	2.60	2.98	2.35	2.50	2.42	3.50	4.07	3.46
Class E	1.26	2.11	2.67	2.45	3.77	3.86	2.40	3.03	3.75	5.30	5.93	5.07
Class F	8.82	12.34	12.97	8.55	12.58	12.63	10.63	13.29	14.56	22.55	25.53	20.97
Average	**2.24**	**3.31**	**3.54**	**2.79**	**3.94**	**4.03**	**3.23**	**3.89**	**4.23**	**6.42**	**7.28**	**6.05**

Supported by the French ANR ARTEFaCT project, by COVIBE project funded by Brittany region and by the European Celtic-Plus project 4KREPROSYS.