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Coding Tree Early Termination for Fast HEVC Transrating Based on Random Forests

Thiago Bubolz, Mateus Grellert, Bruno Zatt and Guilherme Corrêa
Federal University of Pelotas (UFPel), Pelotas, Brazil
Contact:
tlabubolz@inf.ufpel.edu.br

INTRODUCTION

- **HEVC** bit rates are **40-50%** smaller than in H.264, but the encoding process is up to **500%** more complex **[1]**:
  - Larger number of partitions evaluated in quadtree structure through Rate-Distortion Optimization (RDO);
  - Frame is recursively partitioned in **Coding Units** (**CUs**).
- **Transrating for HEVC is even more complex**, since it comprises decoding and encoding in cascade;

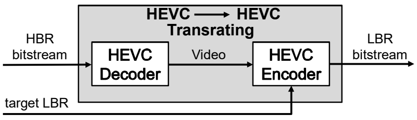

Fig 1: HEVC transrating process

- **This paper proposes an early termination** that stops the recursive CU search earlier:
  - Based on the correlation between CU depths in *High Bitrate* (**HBR**) to *Low Bitrate* (**LBR**) transrating;
  - Based on ***Random Forests*** trained with HBR and LBR CU data.

PARTITIONING IN HEVC TRANSRATING

- HEVC partitioning is performed in a quadtree structure with square CUs from 64×64 to 8×8 pixels;

Fig 2: Comparison between CU partitions in HBR and LBR bitstreams

- **HBR HEVC → LBR HEVC transrating:**
  - Same video sequence, information reuse.
- **Partitioning correlation analysis** provides the basis for the method proposed in this work (Table I);
- In most cases, the same CU size used in **HBR** (or a larger CU size) is employed during the **LBR** transrating;
- However, partitioning also depends on other features.

Table I: HBR and LBR CU size correlation

	CU size	Low bitrate (%)			
		64×64	32×32	16×16	8×8
High bitrate	64×64	**93.1**	5.7	0.8	0.3
	32×32	41.8	**53.9**	3.7	0.6
	16×16	19.1	22.1	**56.0**	2.6
	8×8	13.9	16.6	21.5	**47.8**

RANDOM FORESTS FOR CU SIZE DECISION

- **Data mining** with 25 features collected from HBR decoding;
- **Gini Importance** (GI) calculated for each feature;
- Most important features used to train **Random Forests.**

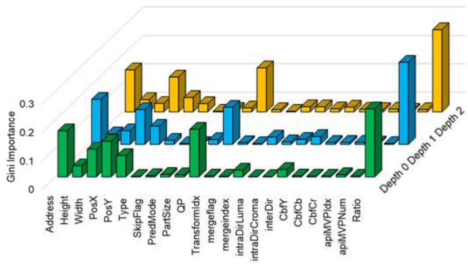

Fig 3: Gini Importance (GI) for each feature.

PROPOSED SCHEME

- Forests with up to 1000 trees were trained, but accuracy did not improve significantly with more than 20 trees;
- Based on features extracted from the HBR decoding, Random Forests decide whether **the HBR CU map** must be **updated** or **maintained** in the new LBR CU map;
- The LBR CU map is used do **constrain** the CU splitting process in the encoding process (Fig. 3).

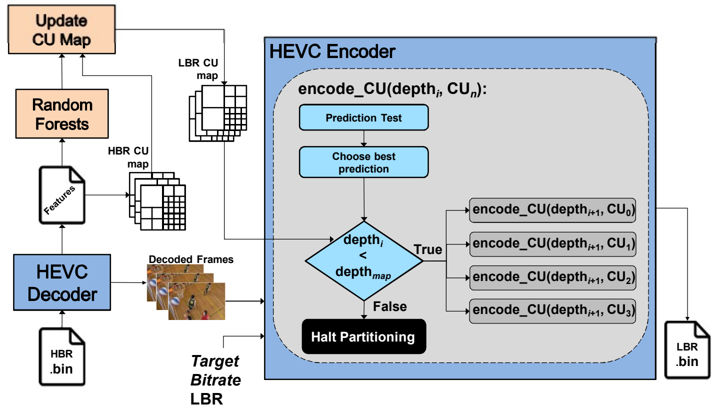

Fig 3: Proposed transrating scheme using Random Forests.

RESULTS AND CONCLUSIONS

- **Compression efficiency** was measured in Bjøntegaard Delta-rate (BD-rate);
- **Time savings (TS)** were measured as $\mathrm{TS} = \frac{T_{Original} - T_{Modified}}{T_{Original}}$

Table II: Experimental results in terms of BD-rate, BD-PSNR and Time Savings (TS)

Video Sequence	BD-rate (%)	TS (%)	BD-r / TS
Tango	-0.681	50.70	-1.342
CatRobot	-2.423	31.49	-7.694
TrafficFlow	-1.426	32.85	-4.341
DaylightRoad	0.499	33.62	1.485
Kimono	0.764	55.63	1.373
ParkScene	0.601	44.46	1.353
Cactus	1.219	39.07	3.121
BQTerrace	0.979	37.67	2.599
FourPeople	0.730	64.56	1.130
Johnny	0.634	68.56	0.924
ChinaSpeed	0.763	39.31	1.940
SlideShow	1.844	67.14	2.747
Average 4K	-1.008	33.62	-2.996
Average Full HD	0.891	40.04	2.225
Average HD	0.993	44.42	2.235
Average	**0.292**	**47.95**	**0.266**

Table III: Comparison with related works

Related Work	BD-rate (%)	TS (%)	BD-r / TS
Praeter [2]	5.60	61.0	9.180
Yang [3]	2.26	55.0	4.109
Shroeder [4]	0.76	38.4	1.979
Bubolz [5]	0.88	45.4	1.938
Proposed	**0.29**	**47.1**	**0.266**

Experimental Setup:
- HBR set to the bitrate obtained with QP 22;
- LBR set to 80%, 60%, 40%, 20% of HBR;
- 12 video sequences from CTC;
- HM 16.4 (decoder and encoder);
- *Random Access Main* configuration;
- BD-r/TS values multiplied by 100 for better visualization;
- Average results calculated after transrating from HBR to LBR 80%, 60%, 40%, 20%.

- **Summary of obtained results** (Table II)**:**
  - **Average time savings of 47.95%**;
  - Negligible **BD-rate increase of 0.292%**;
  - **BD-r/TS ratio of 0.00266**.
- The strategy is especially useful for **online streaming services** requiring multiple transrating upon user request;
- Better results in terms of **TS**, **BD-rate** and **BD-r/TS** compared with related works in the literature (Table III).

REFERENCES

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[3] Shih-Hsuan Yang et al., "Fast coding-unit mode decision for hevc transrating," In Computer and Information Technology (CIT), 2017 IEEE International Conference on. IEEE, 2017, pp. 93–100.

[4] Damien Schroeder, et al., "Efficient multi-rate video encoding for hevc-based adaptive httpstreaming,"IEEE Transactions on Circuits and systemsfor Video Technology, vol. 28, no. 1, pp. 143–157, 2018.

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