Energy Reduction Opportunities in an HEVC Real-Time Encoder

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I. Motivations

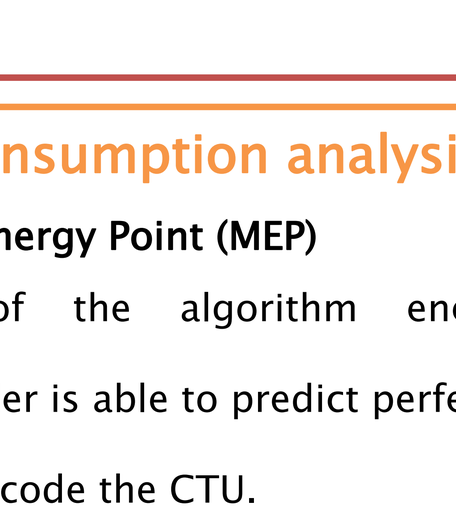
- High Efficiency Video Coding (HEVC): 40% bitrate savings when compared to the widespread H.264/AVC standard.
- Computational complexity of HEVC encoder doubled compare to H.264/AVC.

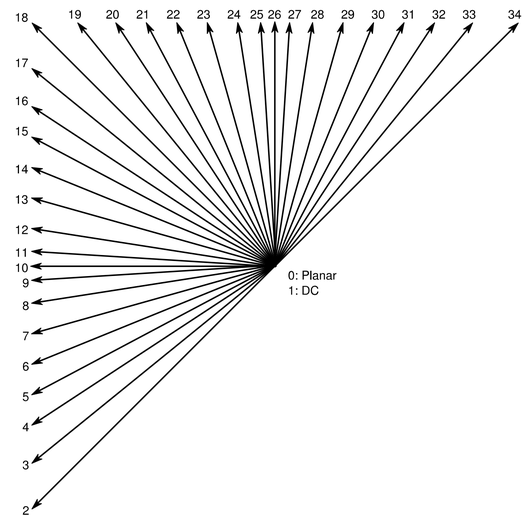
Contribution: Overview of energy reduction opportunities in the real-time Kvazaar encoder.

II. Related Work: Computational Complexity of HEVC encoder

❑ Coding Tree Unit Level

- Coding Tree Unit (CTU): root node of the quad-tree decomposition in Coding Units (CUs).
- **354 encodings** to try all decomposition of a CTU.





❑ Intra prediction Level

- Prediction of a block from neighbor blocks.
- Including residual prediction, transformation, quantization, inverse quantization, inverse transformation and entropy coding.
- **35 different modes** tested.

III. Experimental Setup

- HEVC encoder: real-time software encoder **Kvazaar** (TUT).
- Embedded platform: EmETXei87M0 (Arbor Technology) based on Intel Core i5-4402E processor at 1.6 Ghz.
- Energy measurement: external acquisition board PXI-6280 (National Instrument).
- Data sequences: 22 video sequences including different frame rates, motions, texture characteristics and spatial resolutions.

IV. Coarse-grain energy consumption analysis

❑ Resolution and Frame Rate Level

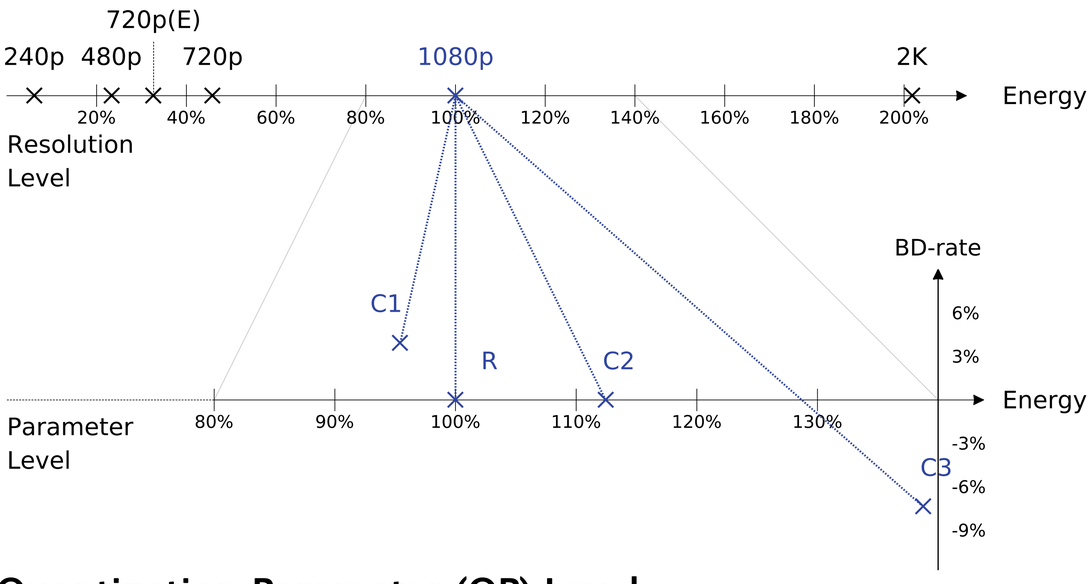
- Have the highest impact on energy consumption of the encoder
- Energy consumption is linearly linked to the number of pixels per frame

❑ Encoder Parameter Level (Intra Encoding)

- In-loop filters (Sample Adaptive Offset + Deblocking Filter)
- Transform skipping
- Rate-Distortion Optimization Quantization (RDOQ)

Normalized energy by resolution and configuration of the coarse-grain analysis

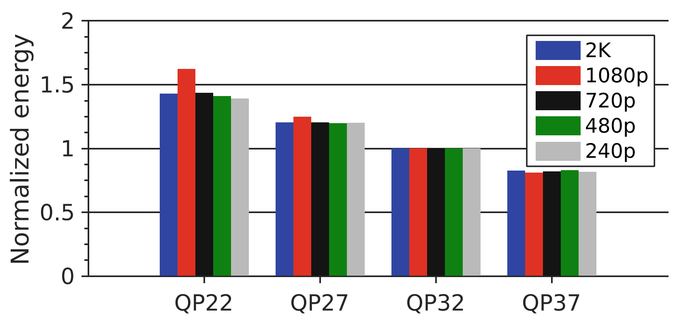
Tool	Configuration case (C)			
	C1	R	C2	C3
Filter (SAO + DF)	D	E	E	E
Transform skipping	D	D	E	D
RDOQ	D	D	D	E



❑ Quantization Parameter (QP) Level

- Energy consumption increase as QP decrease

QP impacted by resolution



V. Fine-grain energy consumption analysis

❑ Determination of the Minimal Energy Point (MEP)

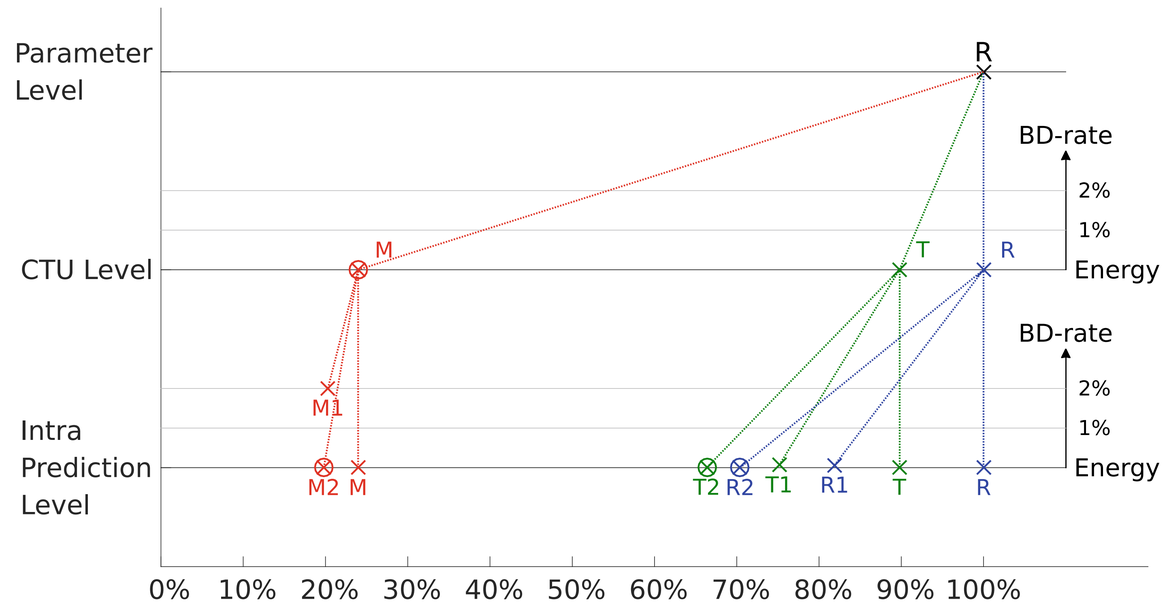
- Theoretical lower bounds of the algorithm energy consumption of an algorithm.
- Energy obtained when the encoder is able to predict perfectly the best solution
- Only one solution is tested to encode the CTU.

❑ Energy Reduction Search Space Definition

- Percentage of energy reduction between a reference point and its associated MEP.
- Two search space defined by their respective MEPs: the search space of CTU level and search space of Intra Prediction Level.

Normalized energy according to CTU and IP configurations, with ⊗ for MEP

Tool	Test Case								
	M2	M1	M	T2	T1	T	R2	R1	R
Early_split_termination	–	–	–	E	E	E	D	D	D
Full_intra_search	–	D	E	–	D	E	–	D	E
MEP-CTU	E	E	E	D	D	D	D	D	D
MEP-IM	E	D	D	E	D	D	E	D	D



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