Model-independent Rate Control for Intra-coding based on Piecewise Linear Approximations

Victor Sanchez
Dept. of Computer Science, University of Warwick, UK. vsanchez@dcs.warwick.ac.uk

This work proposes a rate control (RC) algorithm for intra-coded sequences (I-frames) that departs from using trained models to approximate the rate-distortion (R-D) characteristics of the video sequence. The algorithm first selects $N \geq 2$ control points, where each point, $p_i = (\hat{R}_i, \hat{D}_i, QP_i)$, represents the rate, distortion, and QP value, respectively, of the i^{th} most similar (to the current block) compressed block within the same frame. The algorithm then uses the $N \geq 2$ control points to approximate a linear R-D relation of the form $\tilde{D}(R) = \tilde{\lambda}R + h$, where $\tilde{\lambda}$ is the slope and h is the distortion intercept; and a linear R-QP relation of the form $\widetilde{QP}(R) = mR + j$, where m is the slope and j is the QP intercept. These linear relations are used to compute the QP value of the current block and drive the encoding process. The algorithm is implemented in the High-Efficiency Video Coding (H.265/HEVC) standard (HM16.8 [1]) and compared against its current R-λ algorithm and our work in [2]. We use the AI profile and a largest coding unit (LCU) of 64×64 samples on the Luma component of various 8-bpp sequences. The accuracy of all algorithms is evaluated in terms of the bit rate error (BRE - %): negative numbers indicate underspending the bit budget, while positive numbers indicate overspending (see Table 1). Evaluations results show that the proposed RC algorithm not only attains the overall target bit rate more accurately than the RC algorithm used by H.265/HEVC algorithm but is also capable of encoding each I-frame at a more constant bit rate according to the overall bit budget. As part of our future work, we plan to extend this algorithm for predicted frames (P-frames) and to be used on high-dimensional medical images [3,4].

Table 1: BRE (%) values attained. Target bit rates (R_{target}) are in Mbps.

Sequence	*Characteristics*			R-λ			RC in [2]			Proposed		
	Resolution	fps	R_{target}	|Avg|	Min	Max	|Avg|	Min	Max	|Avg|	Min	Max
flyingGraphics	1920×1080	60	18 36 45 57	2.23	-7.69	1.81	1.08	-1.42	1.02	0.08	-0.92	0.97
map	1280×720	60	2 3 5 7	1.34	-5.29	6.32	1.04	-4.64	6.83	0.87	-1.08	1.01
missionCtrlClip3	1920×1080	60	18 36 45 57	4.89	-11.56	1.47	1.09	-2.57	0.23	0.10	-0.32	0.02
slideShow	1280×720	20	2 4 6 8	2.31	-2.45	2.10	0.97	-1.03	0.45	0.21	-0.03	0.08
slideEditing	1280×720	30	2 4 6 8	0.68	-1.34	0.98	0.89	-0.32	0.04	0.03	-0.02	0.02
chinaSpeed	1024×768	30	2 4 6 8	1.03	0.13	1.03	0.43	0.02	0.13	0.02	0.01	0.02
kimono	1920×1080	24	1.5 4 8 12	0.03	-0.04	0.01	0.02	-0.02	0.01	0.01	0.00	0.01
parkScene	1920×1080	24	1.5 4 8 12	0.02	-0.02	0.01	0.01	0.00	0.01	0.01	0.00	0.01

References

[1] HEVC Software, HM16.8, Accessed February 16, 2019, https://hevc.hhi.fraunhofer.de/svn/svn_HEVCSoftware/tags/HM-16.8/

[2] V. Sanchez, "Rate Control for HEVC Intra-Coding based on Piecewise Linear Approximations," Proc. 2018 *IEEE Int. Conf. on Acoustics, Speech and Signal Processing*, pp. 1782-1786, April 2018.

[3] V. Sanchez, F. Auli-Llinas, J. Bartrina-Rapesta, and J. Serra-Sagrista, "HEVC-based Lossless Compression of Whole Slide Pathology Images," Proc. 2014 *IEEE Global Conf. on Signal and Inf. Processing*, pp. 297-301, December 2014.

[4] V. Sanchez, P. Nasiopoulos, and R. Abugharbieh, "Efficient 4D Motion Compensated Lossless Compression of Dynamic Volumetric Medical Image Data," Proc. 2008 *Int. Conf. on Acoustics, Speech and Signal Processing*, pp. 549-552, April 2008.