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Title:	**Corrected operation of ALF encoding with perceptually optimized QP adaptation**
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Purpose:	Proposal

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Abstract

In JVET-H0047, the authors proposed a CTU-wise subjectively optimized QP adaptation (QPA) along with a correspondingly weighted PSNR (WPSNR) distortion measure. This QPA approach was further improved in JVET-K0206 and accepted for integration into (and optional activation in) the VTM/BMS software.

While studying the adaptive loop filter (ALF) recently integrated into the VTM/BMS software, the authors noticed that the respective encoder-side algorithms and decisions related to the CTU-wise (de)activation of the ALF tool depend on a Lagrangian parameter λ_{slice} derived from the *fixed slice-wise* QP, i. e., the QP_{slice} associated with the given slice. This document proposes to utilize, instead of λ_{slice}, a *CTU-wise* Lagrange parameter λ_{ctu} in the CTU related ALF encoding algorithms and decisions whenever the perceptual QPA is enabled for encoding. Given that the desired λ_{ctu} data for each CTU are already calculated inside the QPA method executed prior to the ALF encoder method, said λ_{ctu} values only need to be accessed by the affected ALF encoding routine, which does *not* increase the coding complexity or run-time. Bjøntegaard delta (BD) WPSNR statistics confirm the subjective benefit of the proposed correction to the VTM/BMS software.

It is suggested to adopt the proposed modification to the ALF encoder in the next version of the VTM/BMS software. Note that this change does *not* affect fixed QP coding as specified in the Common Test Conditions.

1 Proposed Change to the ALF Encoder

The subjectively optimized QPA method introduced in [1] and further improved in [2] adapts, before coding of a CTU, the employed "local" QP, called QP_{ctu} hereafter, as well as the Lagrange parameter λ_{ctu} such that

$$QP_{\text{ctu}} = QP_{\text{slice}} - \lfloor 3 \log_2 w_k \rceil, \quad \lambda_{\text{ctu}} = \frac{\lambda_{\text{slice}}}{w_{\text{ctu}}},$$

where w_{ctu} is the CTU-wise perceptual weight, also referred to as visual sensitivity measure, derived in the QPA algorithm [1], [2]. In other words, both the quantization and the Lagrange parameter are adapted to the input image characteristics on a CTU-by-CTU basis for visually optimal quality of the reconstructed videos. When the QPA routine is disabled, $w_{\text{ctu}} = 1$ is assumed, which implies that $QP_{\text{ctu}} = QP_{\text{slice}}$, $\lambda_{\text{ctu}} = \lambda_{\text{slice}}$.

The adaptive loop filter (ALF) integrated into VTM/BMS software version 2 [3] does not employ the CTU-wise Lagrange parameter, not even in its CTU-by-CTU decisions; see function *deriveCtbAlfEnableFlags*() in the VTM/BMS encoder software. Thus, even while encoding with --PerceptQPA = 1 (i. e., enabled QPA), λ_{slice} is used, which likely limits the coding performance unnecessarily in terms of perceptual quality.

The proposed correction, therefore, is to save the λ_{ctu} values obtained during QPA and to utilize them inside the *deriveCtbAlfEnableFlags*() procedure as well. Note that this change does not require additional memory (an existing storage vector can be reused) and does not affect the VTM/BMS **de**coder (it is non-normative). Table 1 indicates the positive effect of the correction on the CTC sequence set in terms of BD WPSNR gains.

***Table 1**. Bjøntegaard delta (BD) [5] WPSNR results for QPA enabled VTM 2.1 with vs. without the proposed encoder change for the SDR category CTC [4]. Excel sheets with detailed results accompany this document.*

All Intra	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	0.00	–0.09	–0.08	100	101
Class A2	0.00	0.00	0.00	100	101
Class B	0.00	–0.01	–0.01	100	99
Class C	0.00	–0.01	0.00	100	98
Class E	0.00	–0.01	–0.01	100	100
Overall	0.00	–0.02	–0.02	100	99
Random Access	**Gain Y** (%)	**Gain Cb** (%)	**Gain Cr** (%)	**Time Enc.** (%)	**Time Dec.** (%)
Class A1	–0.02	–0.28	–0.35	100	99
Class A2	–0.01	–0.07	0.08	99	94
Class B	–0.05	–0.08	0.01	100	102
Class C	0.00	–0.11	–0.18	100	95
Class E					
Overall	–0.03	**–0.13**	**–0.10**	100	98

2 Summary and Conclusion

This input document proposed a straightforward change to the ALF encoding routine related to a CTU-wise activation/deactivation in case of VTM/BMS bit-stream encoding with enabled perceptually optimized QP adaptation (QPA) according to [1], [2]. Fixed-QP coding according to JVET's Common Test Conditions [4] is not affected by the proposed encoder-side change. With activated QPA, Bjøntegaard delta (BD) WPSNR measures show small but significant gains due to the proposal, while the encoder run-time remains at 100%.

In light of the outcome of this investigation, the authors recommend the integration of the proposed modifications to the ALF encoder into the next version of the VTM software after the 12th JVET meeting in Macao. VTM 2.1 encoded bit-streams applying the proposed change are available to JVET members upon request, and the software is located at https://vcgit.hhi.fraunhofer.de/crhelmrich/VVCSoftware_BMS/tree/L0181-Corrected-ALF-Enc-with-Perceptual-QPA.

3 References

[1] S. Bosse, C. Helmrich, H. Schwarz, D. Marpe, T. Wiegand, "Perceptually Optimized QP Adaptation and Associated Distortion Measure," JVET-H0047, Macao, China, Oct. 2017.

[2] C. Helmrich, H. Schwarz, D. Marpe, and T. Wiegand, "Improved Perceptually Optimized QP Adaptation and Associated Distortion Measure," JVET-K0206, Ljubljana, Slovenia, July 2018.

[3] B. Bross, J. Chen, S. Liu, "Versatile Video Coding (Draft 2)," JVET-K1001, ver. 6/7, Sep./Oct. 2018.

[4] F. Bossen, J. Boyce, K. Sühring, X. Li, V. Seregin, "JVET Common Test Conditions and Software Reference Configurations for SDR Video," JVET-K1010, Ljubljana, Slovenia, July 2018.

[5] G. Bjøntegaard, "Calculation of Average PSNR Differences between RD-Curves," VCEG-M33, Austin, USA, Mar. 2001.

4 Patent Rights Declaration(s)

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