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GOP Level Quality Dependency Based Frame Level Rate Control Algorithm

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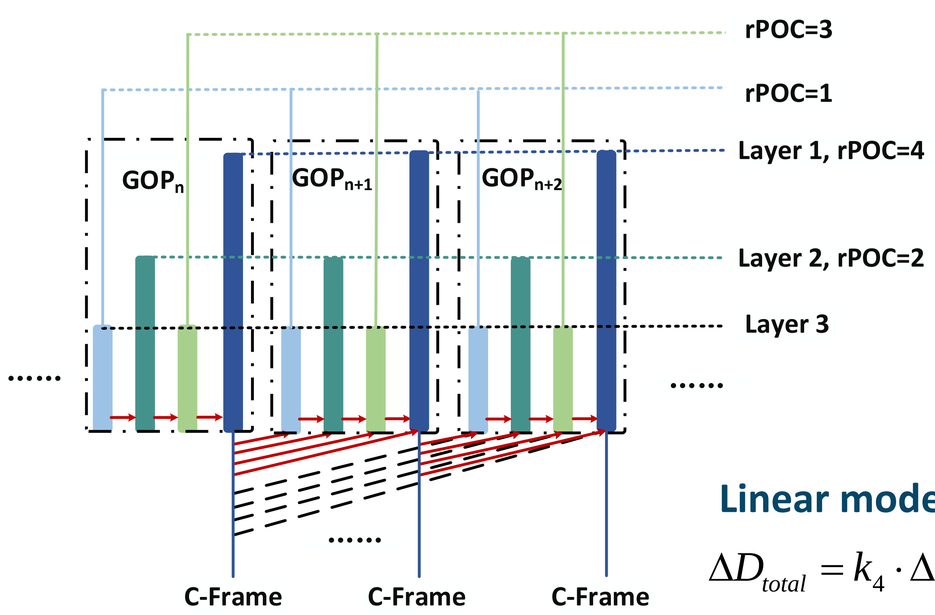
NPU

Introduction

Rate control is crucial to meet bit budget and channel bandwidth. Low delay hierarchical coding structure: **quality dependency**.

Contributions
- A GOP level quality dependency model is built to describe the total influences of frames in current GOP on subsequent frames.
- A frame level bit allocation method based on GOP level quality dependency model is proposed.

GOP Level Quality Dependency Model



Linear model

$$\Delta D_{total} = k_4 \cdot \Delta D_{CFG_n}$$

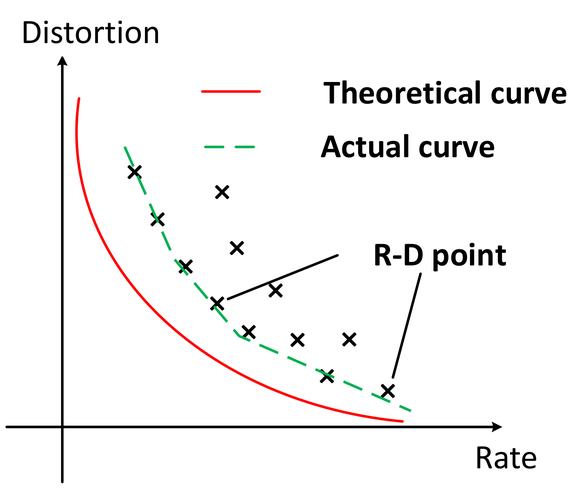
Quality Dependency Chain:

- The C-Frame of GOP$_n$ affects GOP$_{n+1}$.
- The C-Frame of GOP$_{n+1}$ which affected by GOP$_n$ also affects GOP$_{n+2}$.

Rate control Algorithm

Global rate-distortion optimization :

$$J = \sum_{i=1}^{N} D_{tG} + \lambda_g \left(\sum_{i=1}^{N} bpp_i - N \cdot bpp_{tG} \right)$$



- Global Lagrange multiplier.

$$bpp_i = \left(\frac{\omega_i \cdot \lambda_g}{\alpha_i} \right)^{\frac{1}{\beta_i}}$$

ω_i: related to GOP level Quality Dependency.

Bit mismatch question

After encoding, there always exists **bit mismatch** between target bpp and actual bpp.

Our method: after frames in a GOP encoded, for the remaining frames in a GOP, remaining bits is recalculated and a **new rate-distortion optimization** is rebuilt.

$$J = \sum_{i=j}^{N} \left(D_i + k_i \cdot D_i \right) + \lambda_g^{new} \cdot \left(\sum_{i=j}^{N} bpp_i - \left(N - j + 1 \right) \cdot bpp_{TarGOP}^{new} \right)$$

Use **actual distortion** of a frame to update the model parameters of R-λ model.

$$\beta_{new} = -\frac{bpp_{act} \times \lambda_{act}}{D_{act}} - 1 \qquad \alpha_{new} = \frac{\lambda_{act}}{bpp_{act}^{\beta_{new}}}$$

Experimental Results 1 （Rate Control accuracy）

Evaluated by average **bit rate error** under 4 target bits (4 QP compress by HM-16.7).

Li-Frame[1]		Guo-Frame[2]		Proposed	
LDB	LDP	LDB	LDP	LDB	LDP
34.851	33.208	31.264	33.161	29.914	28.409

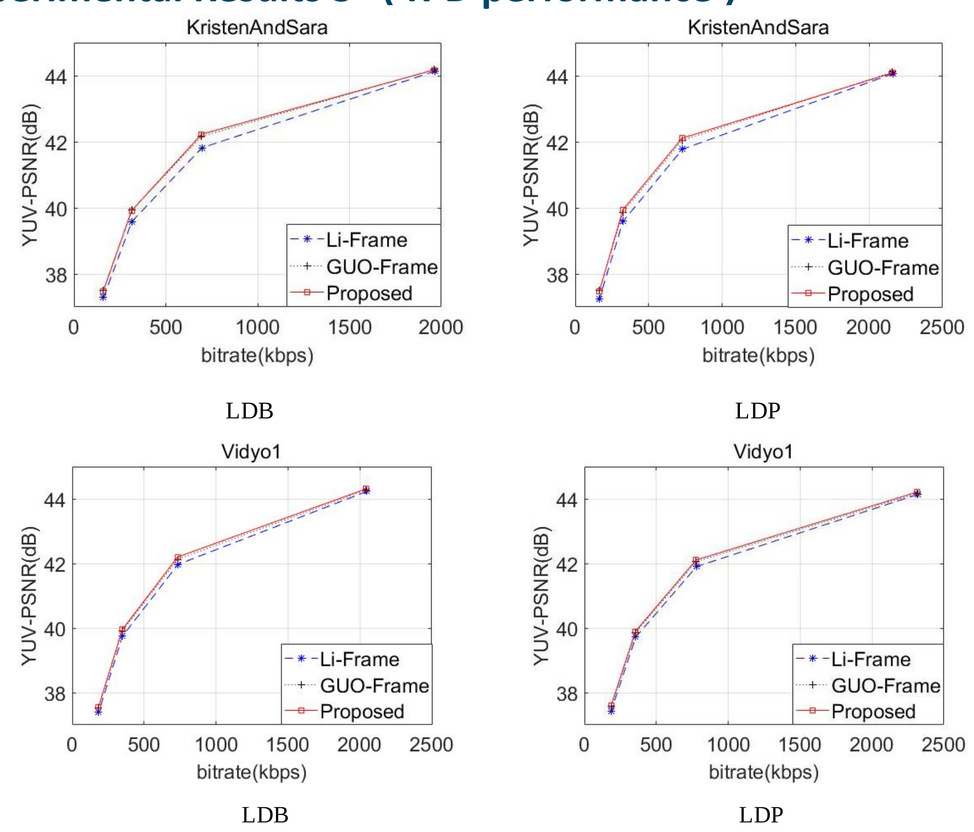
Experimental Results 2 （Coding complexity）

Evaluated by average **encoding time ratio** which compared with Li-Frame and Guo-Frame RC algorithms.

Algorithm	LDB	LDP
Proposed vs Li-Frame	101.96	102.04
Proposed vs Guo-Frame	100.66	100.45

Some parameter is obtained by pre-encoding. so, additional encoding time is required but not much.

Experimental Results 3 （R-D performance）



Conclusion

- Better R-D performance.
- Rate control accuracy is better than the other two algorithms.
- Coding complexity is almost as similar as the other two algorithms.

[1] L. Li, B. Li, H. Li, and C. W. Chen, " λ-Domain Optimal Bit Allocation Algorithm for High Efficiency Video Coding," *IEEE Transactions on Circuits and Systems for Video Technology*, vol. 28, no. 1, pp. 130–142, Jan. 2018.

[2] H. Guo, C. Zhu, S. Li, and Y. Gao, "Optimal Bit Allocation at Frame Level for Rate Control in HEVC," *IEEE Transactions on Broadcasting*, pp. 1–12, 2018.