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INTERFRAME-DEPENDENT RATE-QP-DISTORTION MODEL FOR VIDEO CODING AND TRANSMISSION

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Context - Motivation

Rate control in video coding, is crucial to meet strict rate constraints imposed by **ultra-low latency streaming** (e.g. remote surgery or remote driving).
Goal: Excellent match between the encoding rate and the transmission rates.
Contribution : New model of the relation between R_n and QP_n depending on the Mean Square Error (MSE) distortion D_{n-1} for the reference frame n.

Inter-Dependent R-(QP,D) Model

The rate R_n and QP_n of the n-th frame depends on D_{n-1}.

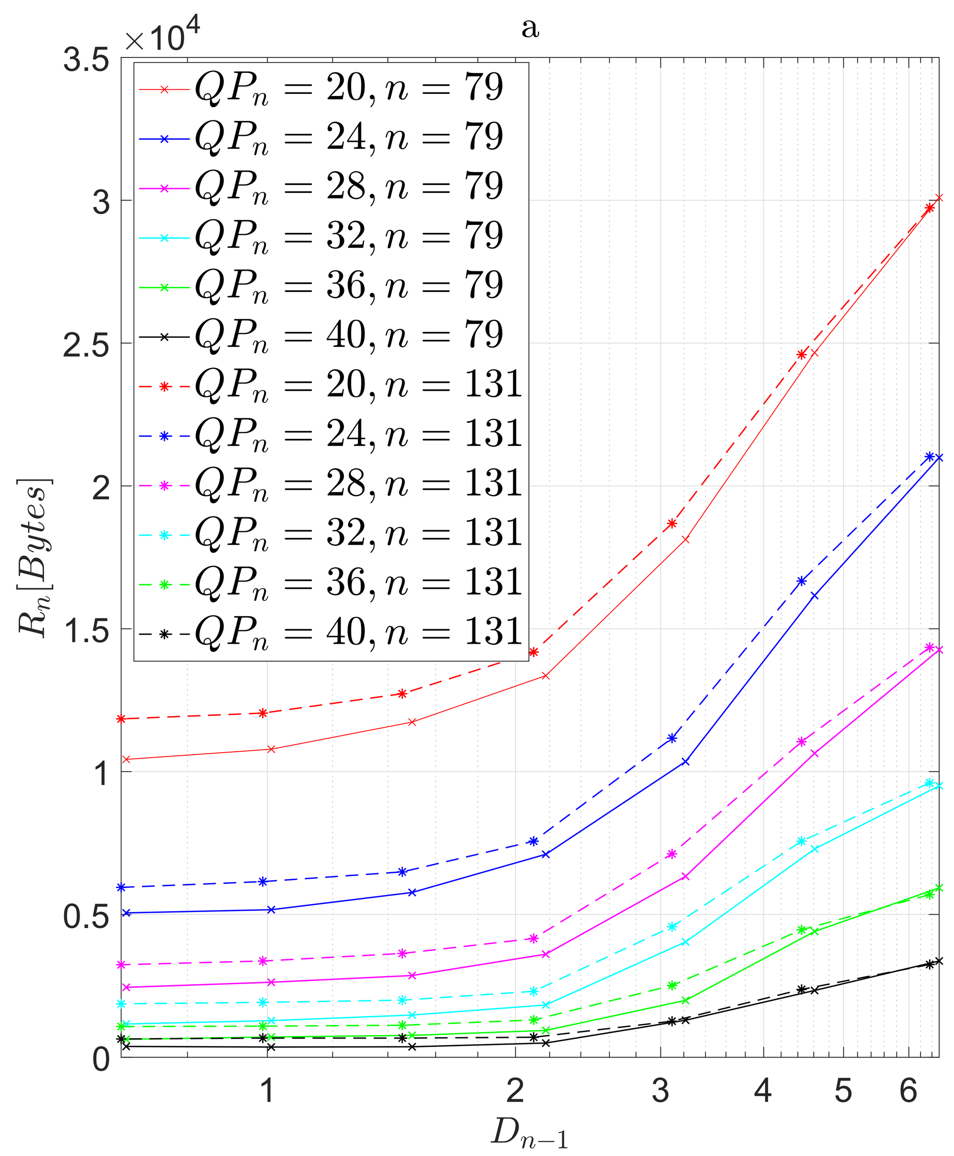

Fig. 1: R_n for the frames $n = 79$ and 131 of *ParkScene* as a function of D_{n-1} for different values of QP_n.

We propose the following R-(QP,D) model:

$$R_n(QP_n, D_{n-1}) = g_1(QP_n) + g_2(QP_n)\left(\tanh\left(g_3(QP_n)\log(D_{n-1}) - g_4(QP_n)\right) + 1\right), \quad (9)$$

with,

$$g_1(QP_n) = p_1 \exp(-p_2 QP_n)$$
$$g_2(QP_n) = p_3(-p_4 log(QP_n) + 1)$$
$$g_3(QP_n) = p_5 QP_n$$
$$g_4(QP_n) = (p_6 QP_n - p_7)^2$$

The performance of the proposed model is compared to (1) , (2) and (3), used at a frame level.

$$R_k = M \cdot N \cdot MAD_k \cdot \left(\frac{p_1}{Q_k^2} + \frac{p_2}{Q_k}\right), \quad (1)$$

$$R_k = p_1 \frac{SAD_k}{Q_k} + p_2. \quad (2)$$

$$R_k = p_1 \cdot M \cdot N \frac{\sigma_k^2}{Q_k^2}. \quad (3)$$

Experiment 1: Constant QP coding

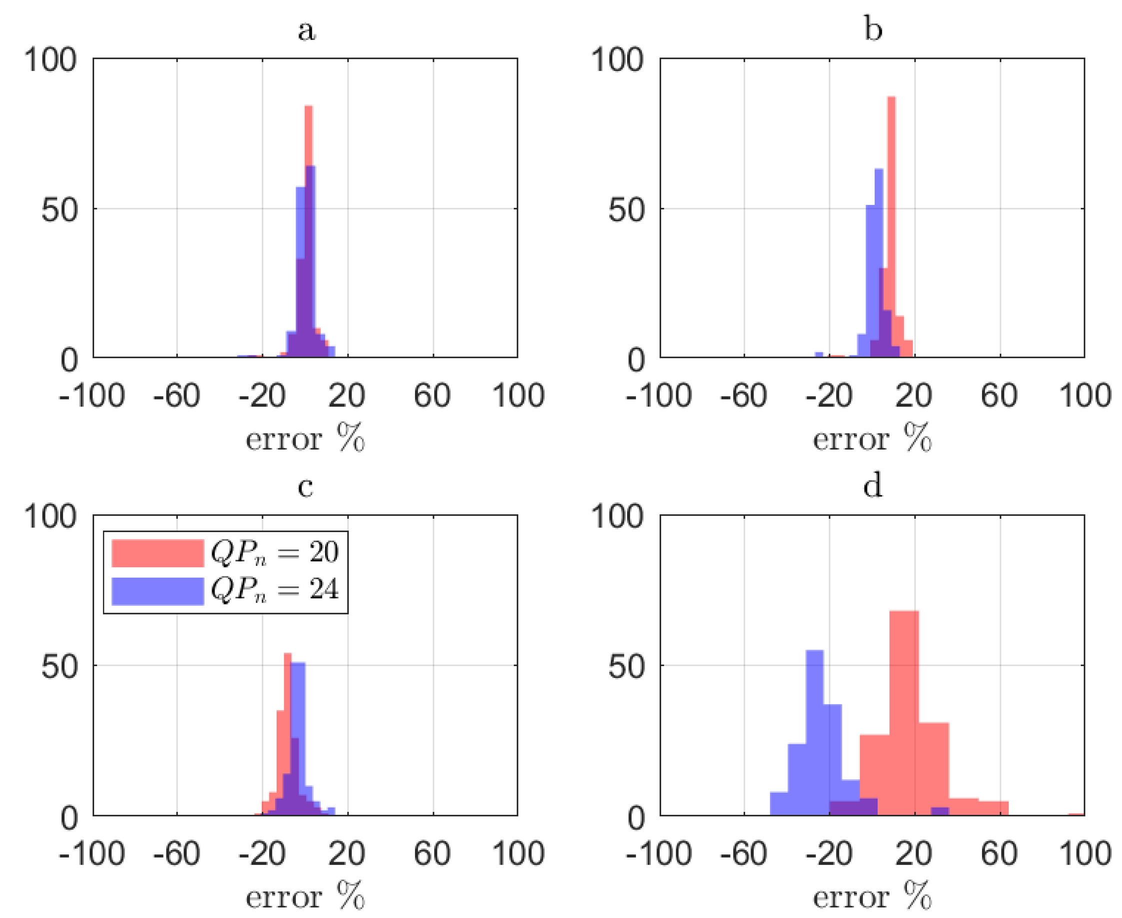

Fig. 2: Histogram of prediction errors for *Tango* at high bitrates.

The proposed model provides the best performance at high bitrates. The performance slightly decreases in low bitrates, but significantly outperforms the three other models.

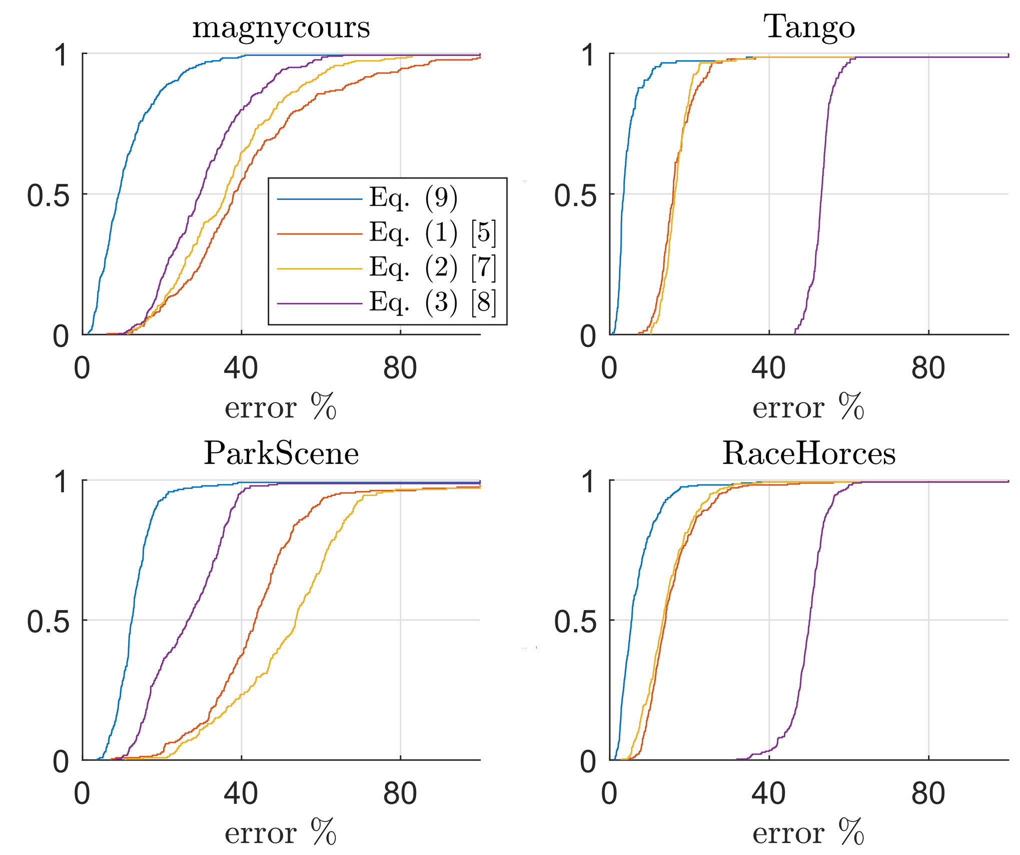

Fig. 3: Average error CDF with constant QP.

Experiment 2: Time-varying QPs.

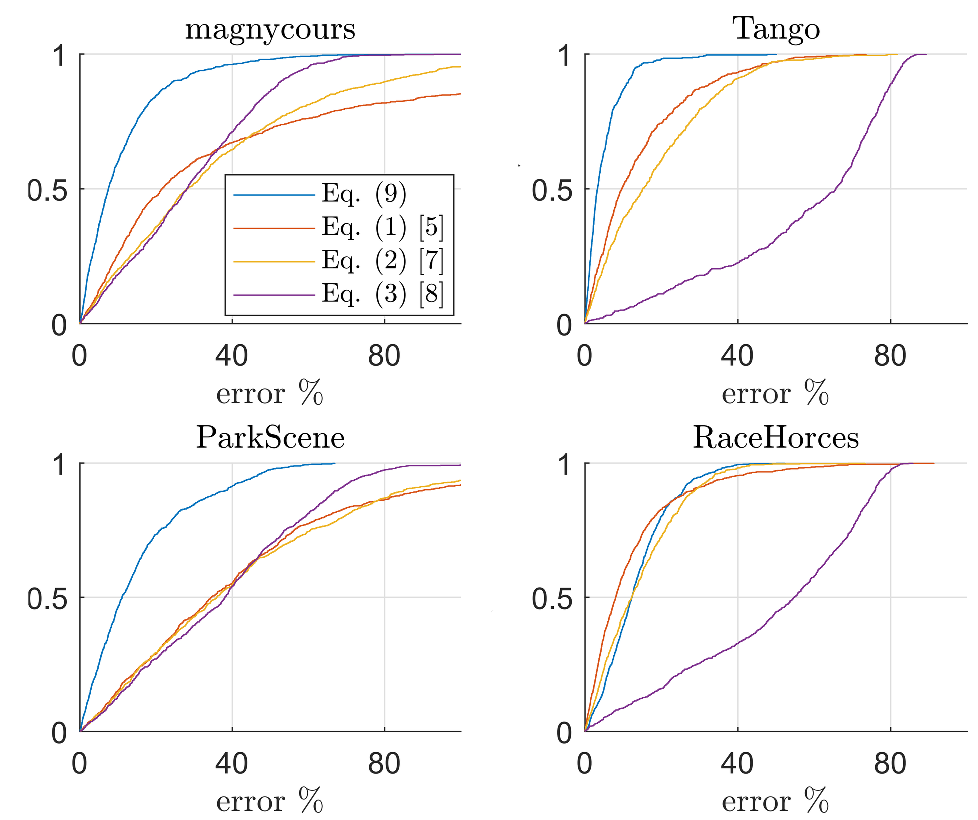

Fig. 4: Error CDF with first-order Markov process variations of QP for each sequences.

Conclusion

- The proposed model outperforms other models in the literature in both constant QP coding and with frame-dependent QP.
- The gains tend to be more significant at low bitrates.