ATHENA UNIVERSITÄT KLAGENFURT

CODA: Content-aware Frame Dropping Algorithm for High Frame-rate Video Streaming

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Outline

Introduction

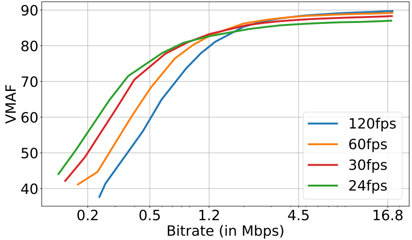
Introduction

High Framerate (HFR) videos

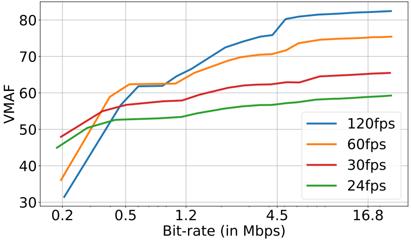
- *High Framerate* (HFR) video streaming enhances the viewing experience and improves visual clarity.[1]
- However, it may lead to an increase of both encoding time complexity and compression artifacts, particularly at lower bitrates.

[1] ITU-R BT.2020-2. "Parameter values for ultra-high definition television systems for production and international programme exchange". In: 2015.

Introduction



(a) HoneyBee



(b) Lips

Figure: Rate-Distortion (RD) curves of UHD encodings of (a) *HoneyBee* and (b) *Lips* sequences for multiple framerates.

Introduction

Variable Framerate (VFR) coding

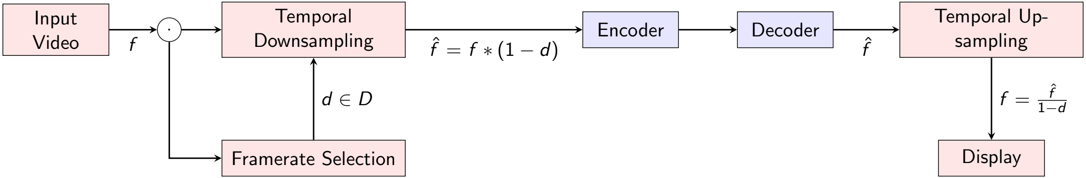


Figure: Block diagram of a variable framerate (VFR) coding scheme[2] in the context of video encoding. f and $\hat{f}$ denote the original framerate of the video and the framerate at which the video is encoded. d represents the frame dropping factor.

[2] G. Herrou et al. "Quality-driven Variable Frame-Rate for Green Video Coding in Broadcast Applications". In: *IEEE Transactions on Circuits and Systems for Video Technology* (2020), pp. 1–1. DOI: 10.1109/TCSVT.2020.3046881.

CODA

CODA

Phase 1: Feature Extraction

Compute texture energy per block

A DCT-based energy function is used to determine the block-wise feature of each frame defined as:

$$H_k = \sum_{i=1}^{w} \sum_{j=1}^{h} e^{\left|\left(\frac{ij}{wh}\right)^2 - 1\right|} \left|DCT(i-1, j-1)\right| \quad (1)$$

where w and h are the width and height of the block, and $DCT(i,j)$ is the (i,j)th DCT component when $i + j > 2$, and 0 otherwise.

The energy values of blocks in a frame is averaged to determine the energy per frame.[3]

[3] Michael King, Zinovi Tauber, and Ze-Nian Li. "A New Energy Function for Segmentation and Compression". In: *2007 IEEE International Conference on Multimedia and Expo*. 2007, pp. 1647–1650. DOI: 10.1109/ICME.2007.4284983.

Proposed Algorithm

Phase 1: Feature Extraction

h_k: SAD of the block level energy values of frame k to that of the previous frame $k-1$.

$$h_k = \frac{SAD(H_k(i) - H_{k-1}(i))}{M} \tag{2}$$

where M denotes the number of CTUs in frame k.

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Phase 2: Framerate prediction

Inputs:

E, h : spatial and temporal complexities

r : video resolution

f_{max} : original framerate

D : set of all frame drop factors $\tilde{d}$

B : set of all target bitrates b (in kbps)

Output: $\hat{f}(b) \ \forall \ b \in B$

Step 1: Determine $\hat{d}(b)$.

$$\hat{d}(b) = d_0 e^{-\frac{\beta_{MA}(r, f_{max}) \cdot h \cdot b}{E}}$$

Step 2: The predicted optimized framerate for the video is given by:

$$\hat{f}(b) = f_{max} \cdot (1 - \hat{d}(b))$$

Evaluation

Evaluation

E and h values are extracted using VCA open-source software.[4]

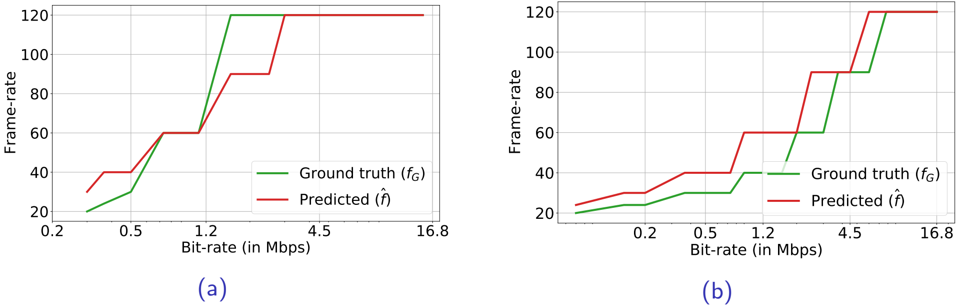
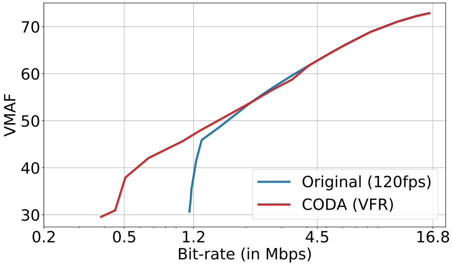


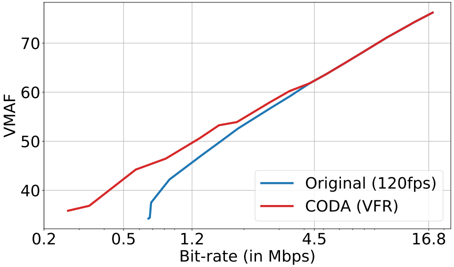
Figure: Optimized framerate prediction results of *Beauty* (a) and *ShakeNDry* (b) sequences. Please note that, depending on the content, the optimized framerate in various bitrates are different.

[4] V. V Menon, C. Feldmann, and H. Amirpour. *VCA*. Version 1.0.0. Available: https://github.com/cd-athena/VCA. Feb. 2022.

Evaluation



(a)



(b)

Figure: Rate-Distortion (RD) results of *Beauty* (a) and *ShakeNDry* (b) sequences for the default encoding and *CODA*-based VFR encoding.

Conclusions and Future Directions

Conclusions

- Presented a content-aware frame dropping algorithm for video streaming applications, especially for HFR videos.
- Predicts the optimized framerate for a set of bitrates defined in a bitrate ladder and resolution for every video, which helps in improving the overall performance of HFR video streaming in terms of encoding time and compression efficiency.
- UHD encoding using the proposed algorithm requires 15.87% fewer bits to maintain the same PSNR and 18.20% fewer bits to maintain the same VMAF as compared to the original framerate encoding. An overall encoding time reduction of 21.82% is also observed.

Q & A

Thank you for your attention!

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