GVFR: Green Variable Frame Rate Encoding for Adaptive Live Streaming

Vignesh V Menon **Samira Afzal**

Institute of Information Technology (ITEC), Alpen-Adria-Universität Austria
vignesh.menon@aau.at **Samira.Afzal@aau.at**
https://athena.itec.aau.at/

UNIVERSITÄT KLAGENFURT
FAKULTÄT FÜR TECHNISCHE WISSENSCHAFTEN
INSTITUT FÜR INFORMATIONSTECHNOLOGIE

ATHENA

BITMOVIN

Agenda

- Motivation and main objectives
- Variable frame rate encoding
- Variable preset encoding
- GVFR
- Evaluation
- Remarks

Motivation

Video streaming accounts for 67.60% current network traffic[1]

- The need to maintain encoding speed for live video streaming to guarantee Quality of Experience (QoE)
- Large-scale video encoding processes consume significant energy, leading to environmental impact

[1] https://www.bbc.com/future/article/20200305-why-your-internet-habits-are-not-as-clean-as-you-think

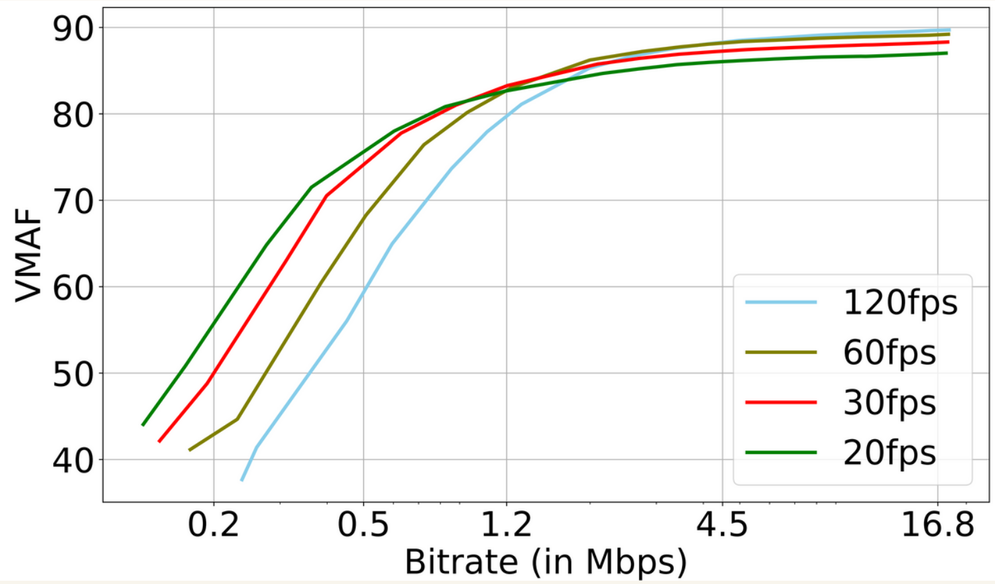
Main Objectives

To optimize live streaming bitrate ladder:

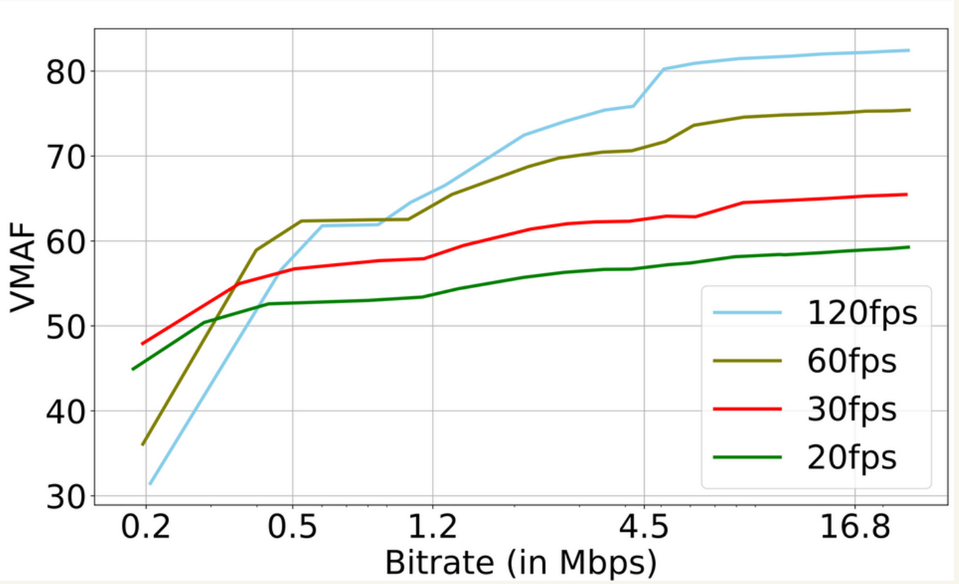
- **Maximize QoE**
- **Minimize overall energy consumption**
- **Real-time approach**

No substantial changes in the current architecture of the streaming service providers

Variable Frame rate Encoding



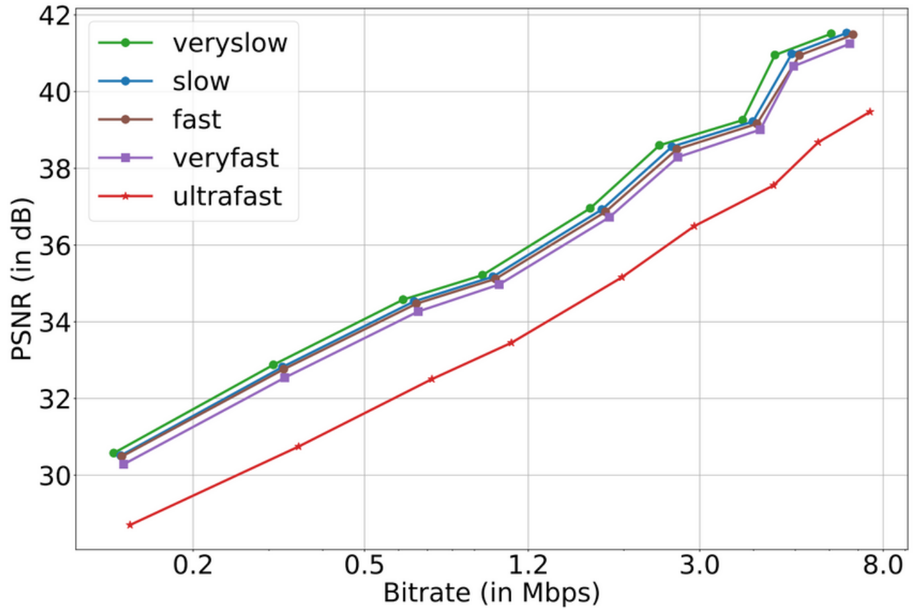
Honeybee

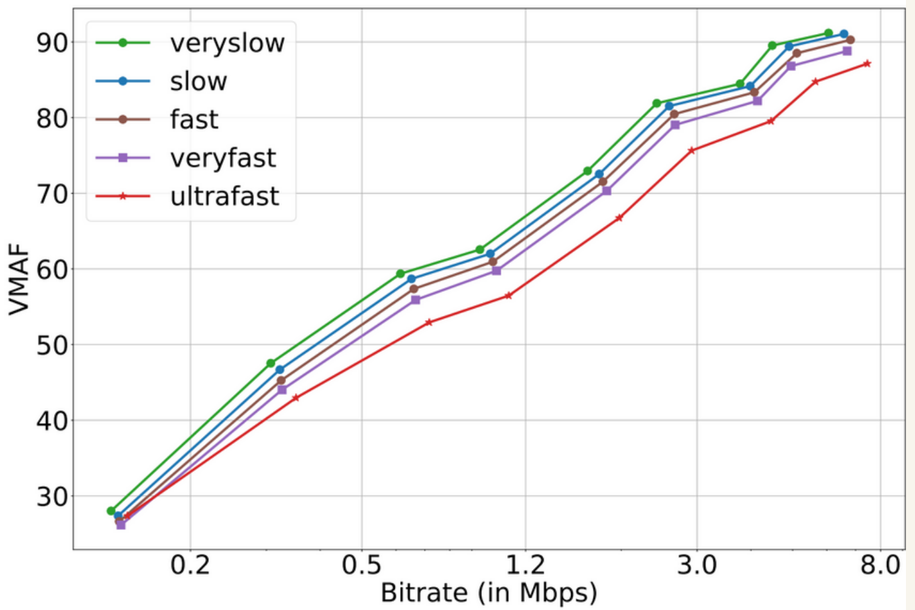


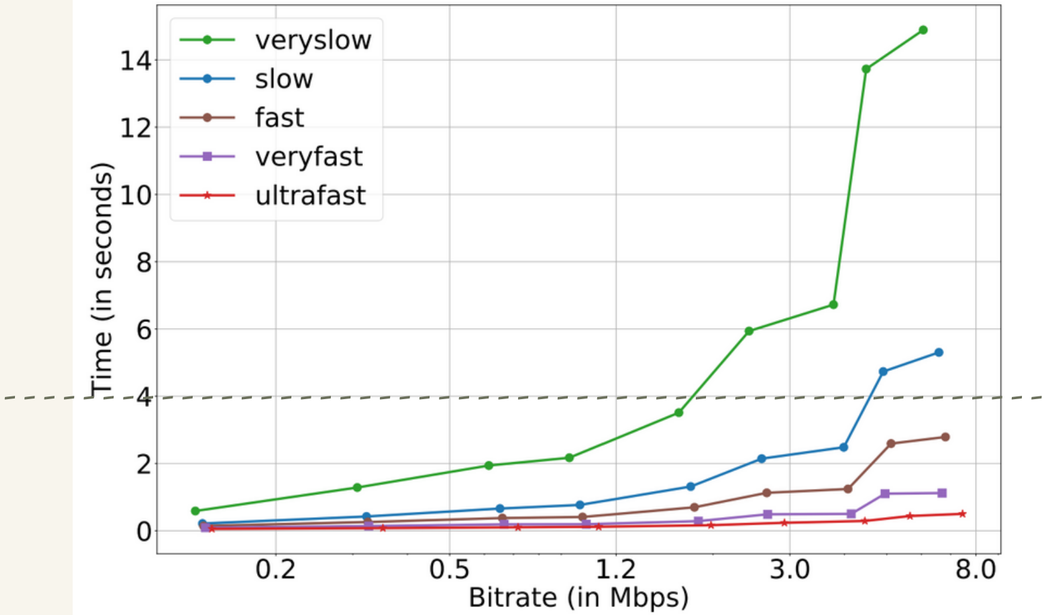
Lips

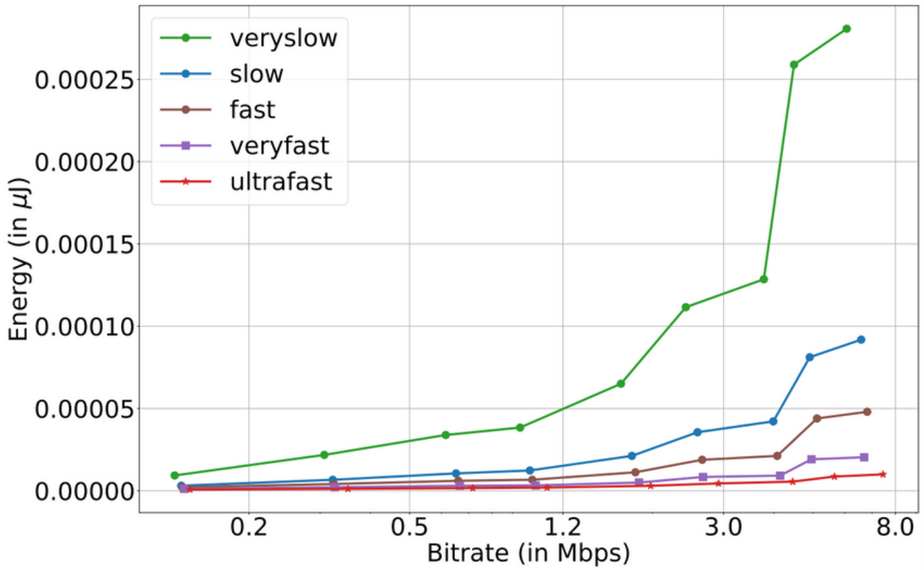
HLS CBR encoding using fast preset of x264 AVC encoder

Variable Preset Encoding

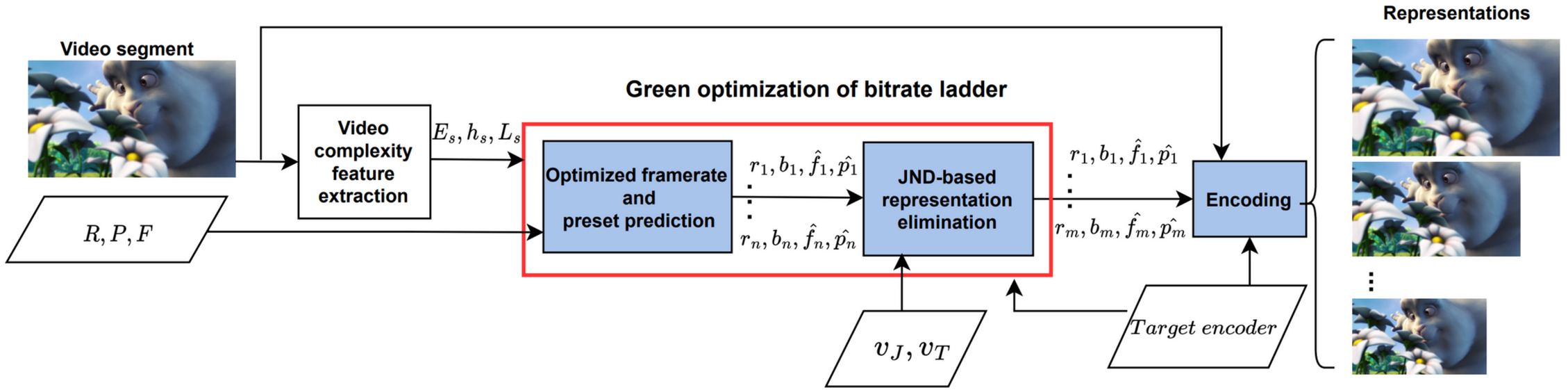






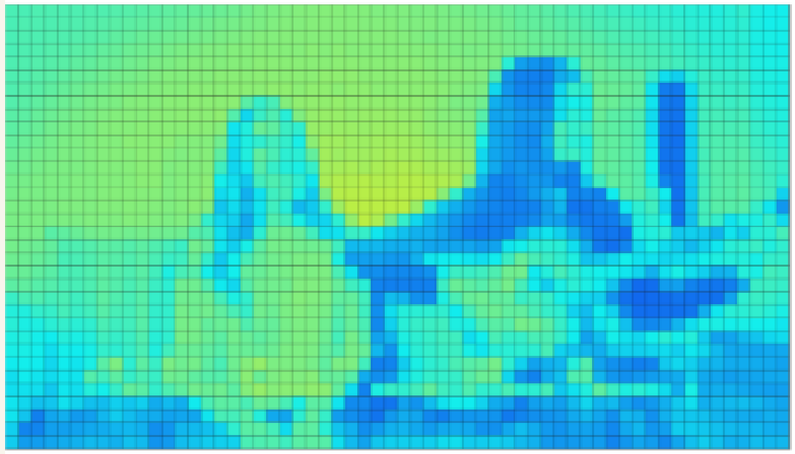


GVFR Architecture Overview

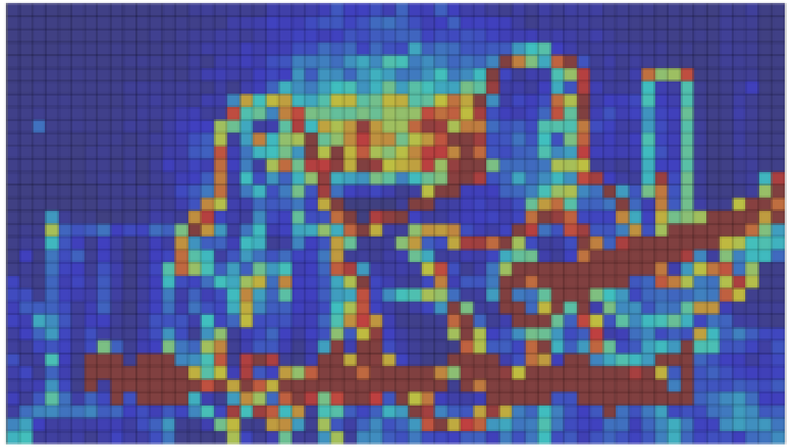


Video Complexity Feature Extraction

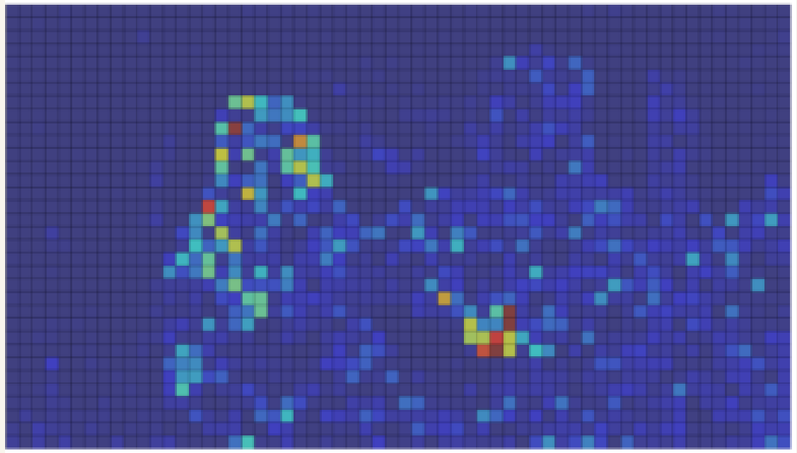
(A) Original Image



(B) L_Y



(C) E_Y



(D) h_Y

Optimized framerate and preset prediction

Inputs:
R: set of representations (*i.e.*, bitrate-resolution pairs)
F: set of target framerates
P: set of encoding presets
for *each video segment* **do**
  Determine E_S, h_S, and L_S
  for *each* $(r, b) \in R$ **do**
    for *each framerate* $f \in F$ **do**
      for *each preset* $p \in P$ **do**
        Encode segment with (r, b, f, p) configuration ;
        Record E_S, h_S, L_S, r, b, f, p, achieved bitrate b', VMAF v, and PSNR p' ;

JND-based Representation Elimination

Inputs:

N : number of bitrates in B

$(r, b, \hat{f}, \hat{p})$ pairs

v_T : max. VMAF threshold

v_J : average target JND

Output: $(r, b, \hat{f}, \hat{p})$ pairs for encoding

Determine $\hat{v}_1$.

$t = 2$

while $t \leq N$ **do**

  Determine $\hat{v}_t$.

  if $\hat{v}_t > v_T$ **then**

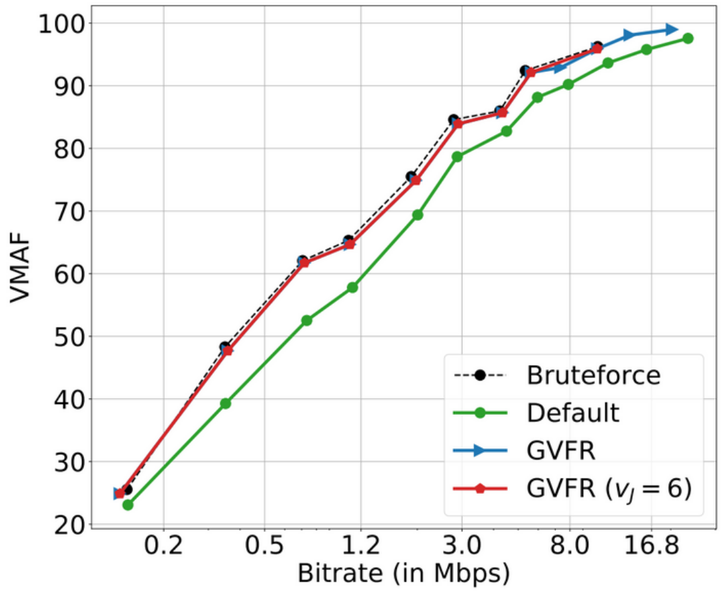
    Eliminate t^{th} representation from the ladder.

  if $\hat{v}_t - \hat{v}_{t-1} < v_J$ **then**

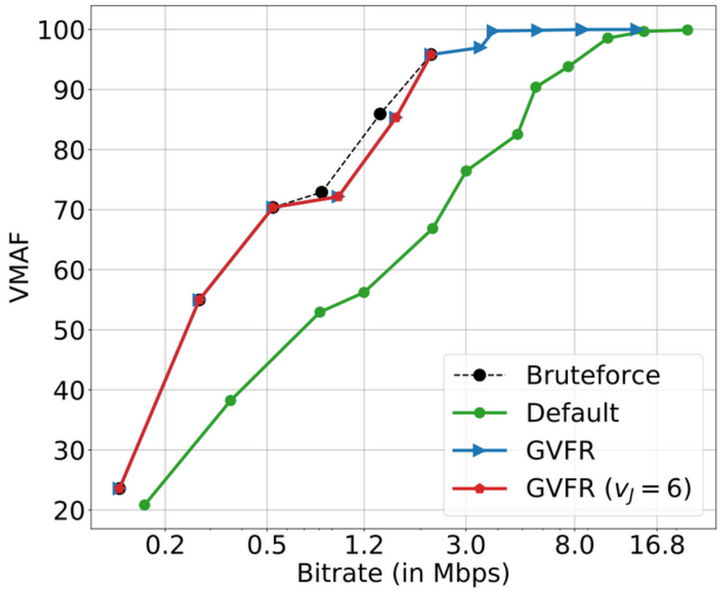
    Eliminate t^{th} representation from the ladder.

  $t++$

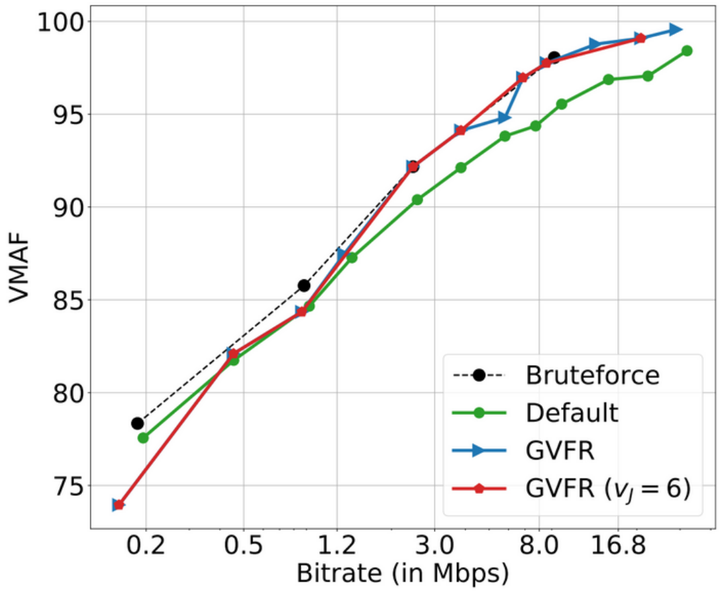
Evaluation



(a) *Bunny_s000*

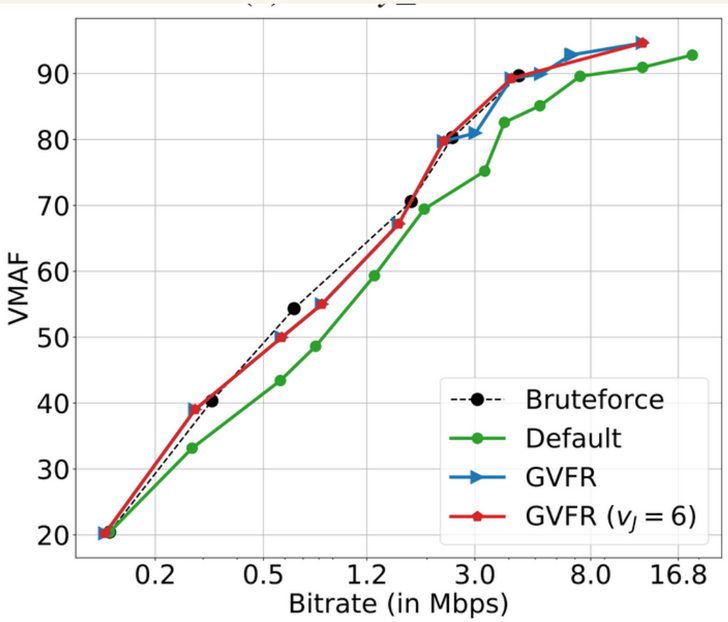


(b) *Characters_s000*

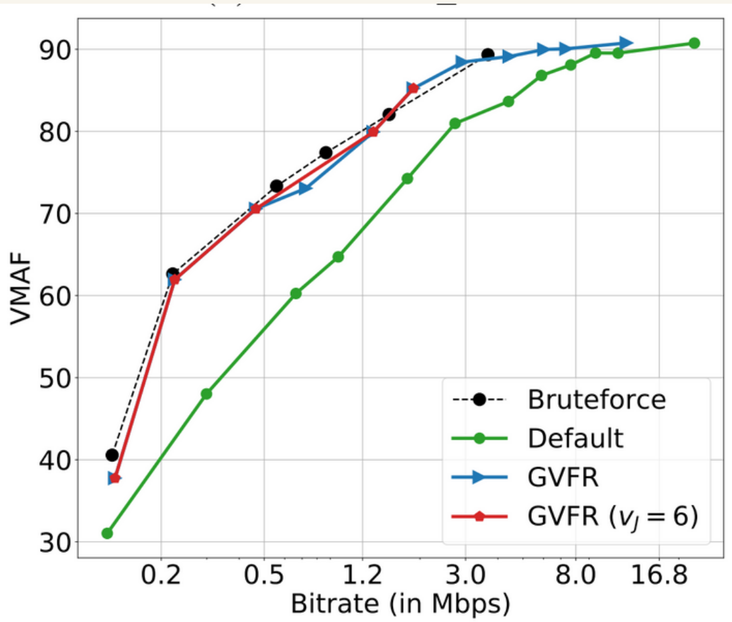


(c) *Eldorado_s000*

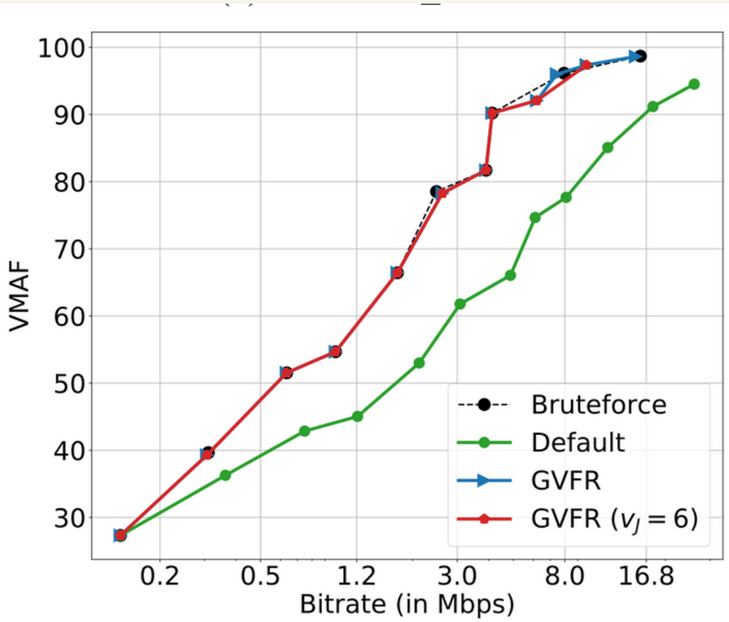
Evaluation



(d) *Eldorado_s005*



(e) *HoneyBee_s000*



(f) *Wood_s000*

Evaluation

Method	BDR_P	BDR_V	BD-PSNR	BD-VMAF	ΔS		ΔE_e	ΔE_s
GVFR	-16.18%	-13.89%	1.44 dB	3.96	-18.18%		-4.45%	-33.05%
GVFR ($v_J = 2$)	-15.97%	-14.01%	1.44 dB	3.96	-29.39%		-7.94%	-50.13%
GVFR ($v_J = 4$)	-15.53%	-13.71%	1.47 dB	4.06	-40.59%		-17.54%	-64.70%
GVFR ($v_J = 6$)	-15.41%	-13.63%	1.71 dB	5.13	-48.40%		-24.50%	-73.78%

Remarks

- GVFR jointly predicts the optimized framerate and encoding preset to encode each representation of the bitrate ladder, yielding the highest compression efficiency and zero-latency encoding
- GVFR is implemented using the x264 open-source video encoder, with an average PSNR and VMAF increase of 1.71 dB and 5.13 points, respectively, for the same bitrate, compared to the standard fastest preset highest framerate encoding
- JND-based representation elimination algorithm also resulted in a **48.40%** reduction in storage space, **24.5%** reduction in encoding energy consumption, and **73.78%** lower storage energy, on average, considering a JND of 6 VMAF points,

Thank you

Have a great day ahead!

Institute of Information Technology (ITEC) Alpen-Adria-Universität Austria
https://itec.aau.at/
Vignesh.Menon@aau.at@aau.at Samira.Afzal@aau.at

UNIVERSITÄT KLAGENFURT
FAKULTÄT FÜR TECHNISCHE WISSENSCHAFTEN
INSTITUT FÜR INFORMATIONSTECHNOLOGIE

ATHENA

GAIA

BITMOVIN