PERCEPTUAL QUALITY EVALUATION OF VARIABLE RESOLUTION VVC VIDEO CODING USING RPR

MHV 2023

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ERICSSON

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Captivate your audience

AGENDA

1. Definition and use cases
2. GOP based RPR control
3. RPR quality evaluation
4. Conclusion and future works

01 Definition and use-cases

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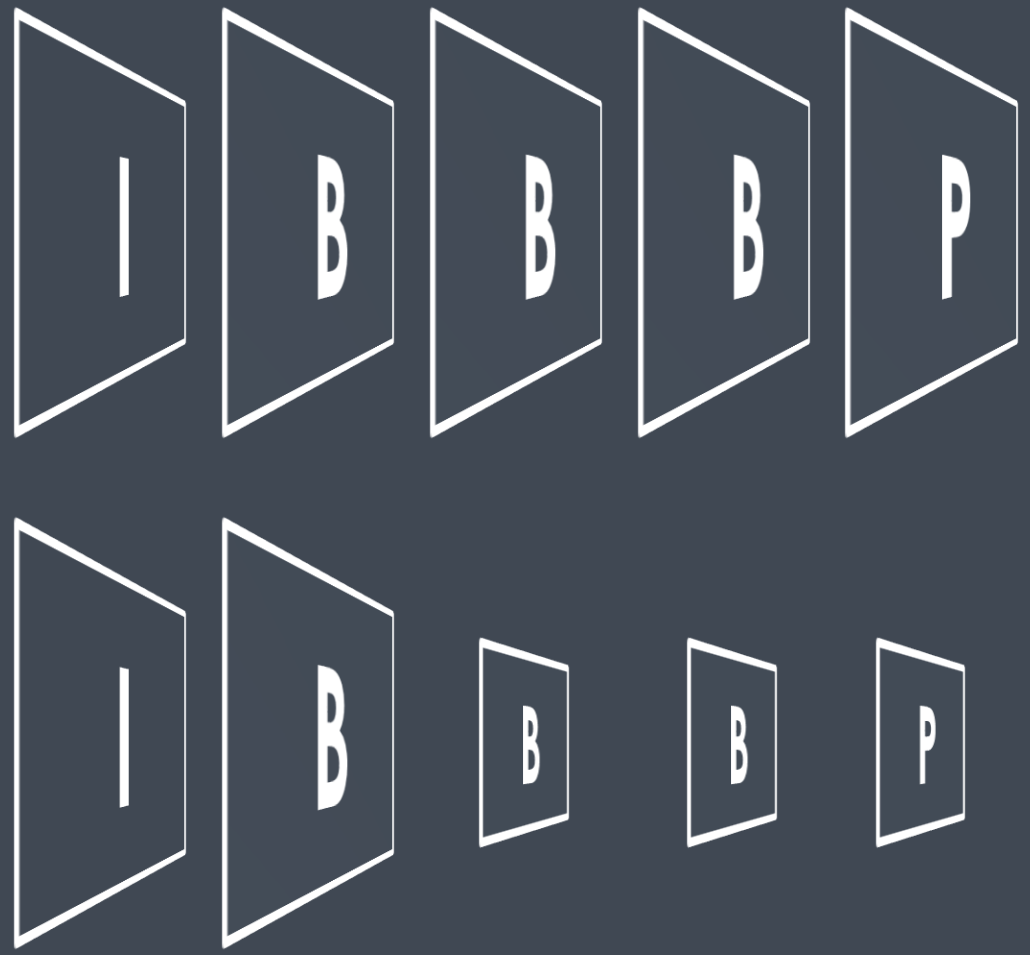
REFERENCE PICTURE RESAMPLING (RPR)

Definition

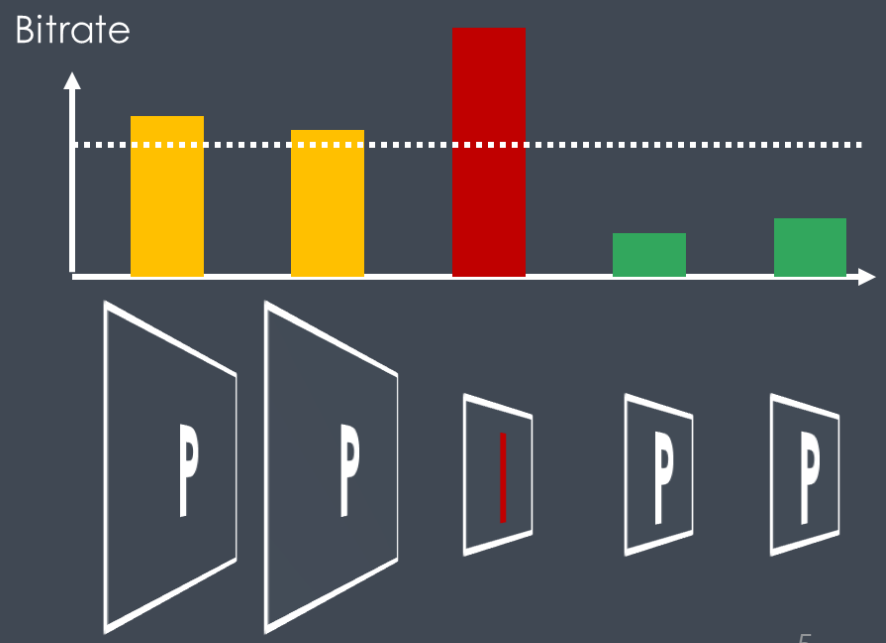
- Versatile Video Coding (2020)
- Temporal prediction as usual
- With a new capability:
- Reference Picture Resampling
  - Allowing a reference frame of a different resolution
  - Not constrained on IRAP
  - **Resolution change at any moment**
  - Enabling scalability from start

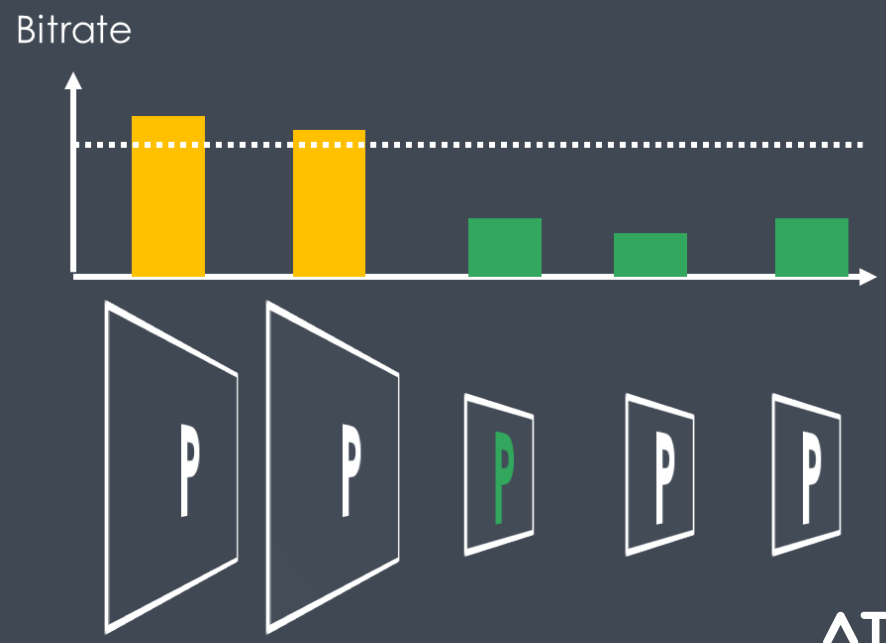


REFERENCE PICTURE RESAMPLING (RPR)

Use-case 1: Network adaptation

- Video conferencing
  - Very low latency
- Adapting to network conditions without IRAP peak bitrate
  - Service continuity





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REFERENCE PICTURE RESAMPLING (RPR)

Use-case 2: cross-profiles open GOP

- Open-GOP structure is useful for video quality temporal stability
- OTT use case
  - Closed GOP at segment switches
- Thanks to RPR and specific tools constraints, Open GOP strategy becomes possible
- Better overall video quality

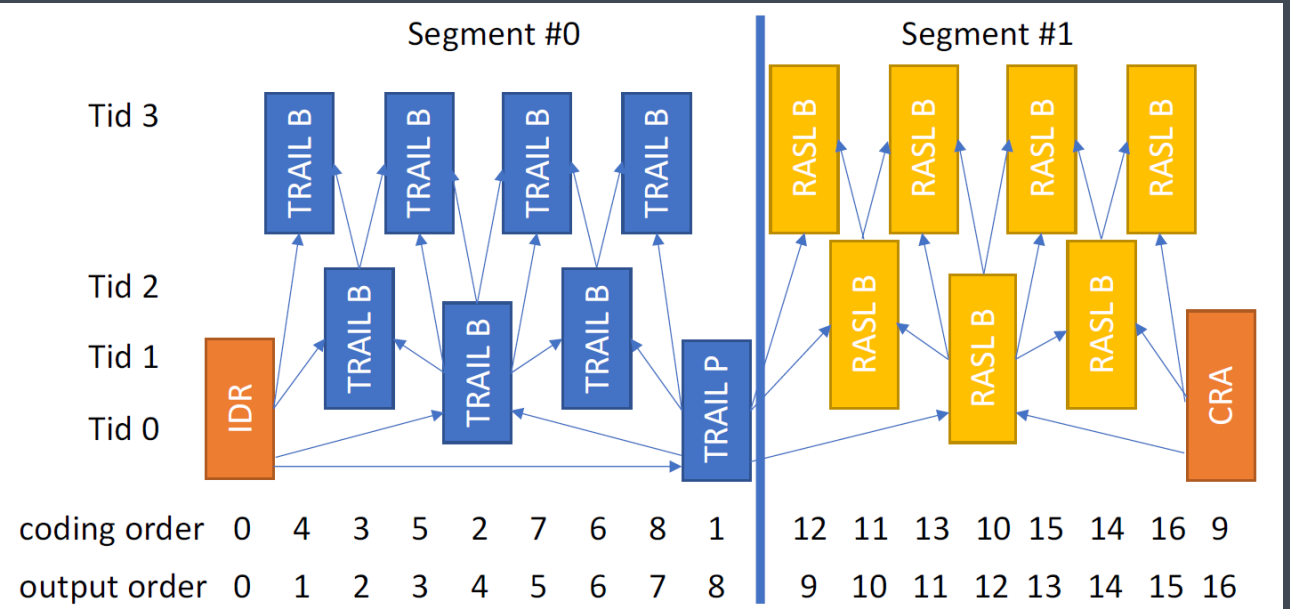


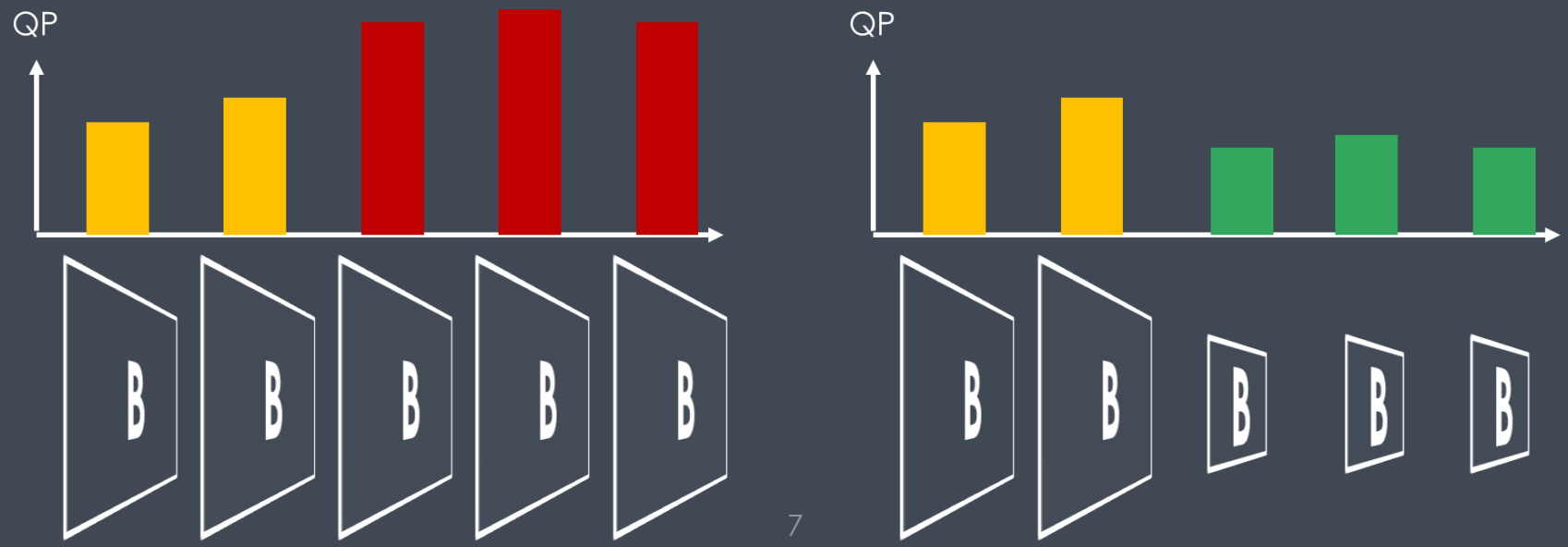
Fig. 1. Two successive segments with different resolution in which the second segment employs an open GOP coding structure with reference pictures from the first segment.

Skupin, Robert et al. "Open GOP Resolution Switching in HTTP Adaptive Streaming with VVC." 2021 Picture Coding Symposium (PCS) (2021): 1-5.

REFERENCE PICTURE RESAMPLING (RPR)

Use-case 3: Rate control

- Optimal resolution for a given bitrate is dependent on the nature of the content
- This well-known observation is particularly relevant for challenging bitrates
- Even without considering network adaptation
- Traditionally, the rate control manages the Quantization Parameter (QP)
- **With RPR, the rate control can handle both QP and resolution**

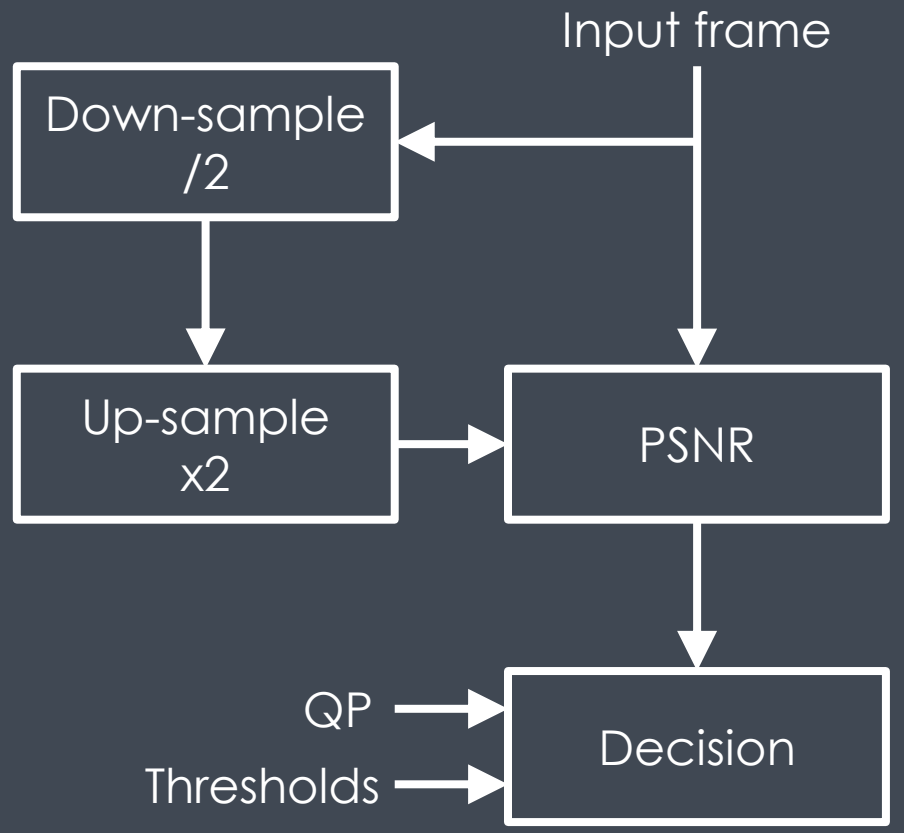


02 GOP based RPR control

GOP-BASED RPR VVC ENCODER CONTROL

Taking control of the resolution

- Implemented in VVC reference model VTM-19.0
- Preprocessing at each GOP
  - Evaluation of the spatial content of the frames
  - Down-sampling decision depending on
    - QP
    - Down-sampling quality impact
- **Up to 10% bitrate saving**



K. Andersson, J. Ström, R. Yu, P. Wennersten, W. Ahmad, "AHG10: GOP-based RPR encoder control", JVET-AB0080-v2, Joint Video Exerts Team (JVET) of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29, 28th Meeting, Mainz, DE, 20–28 October 2022.

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03 RPR quality evaluation

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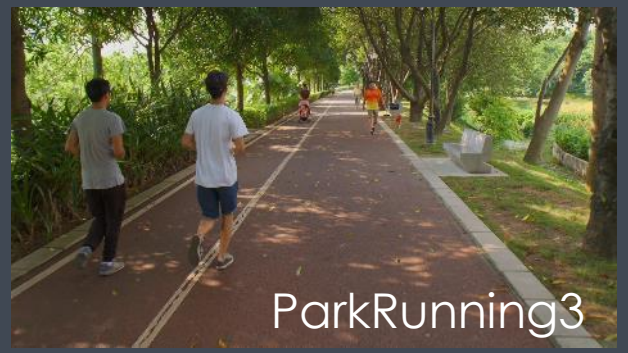
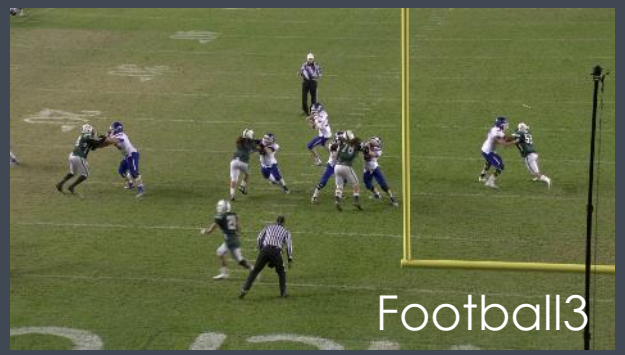
EXPERIMENTAL SETUP

Sequences

- 5 public sequences
- 5 private broadcast sequences





EXPERIMENTAL SETUP

Rate control

- Base QP
  - 37, 40, 43, 46, 49
- Test QP
  - Rate alignment
  - Between -2% and +1% bitrate variation
  - QP adjustment + QP Increment Frame (qpif)
    - QP **X** from frame 0 to qpif
    - QP **X + 1** from frame qpif to end

Sequences	Test QP	Test qpif
Campfire	36	30
	40	-
	43	200
	46	150
	49	-
DaylightRoad2	37	-
	40	-
	43	500
	46	500
	48	50
DrivingPOV3	37	400
	40	-
	42	60
	45	130
	48	280
…	…	…

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EXPERIMENTAL SETUP

RPR effect

- Adaptation to the sequence characteristics is verified
  - % of selection of each sub-resolution

Sequence	QP	4/5	2/3	1/2
Campfire	37	89	0	0
DaylightRoad2	40	95	5	0
DrivingPOV3	40	0	5	95
…	…	…	…	…

Sequence	QP	4/5	2/3	1/2
Campfire	43	11	89	0
DaylightRoad2	46	0	95	5
DrivingPOV3	46	0	0	100
…	…	…	…	…

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OBJECTIVE PERFORMANCE

- Bitrate reduction only
  - Negative BDR score = bitrate gain
- From -3.2% to -22.3%
- **Is there any undesired visual effect not measured by objective metrics?**

Sequence	PSNR BDR savings %	MS-SSIM BDR savings %
Campfire	-8.8	-9.4
DaylightRoad2	-5.5	-8.5
DrivingPOV3	-5.6	-9.5
NeptuneF.3	-3.2	-9.2
ParkRunning3	-6.9	-11.5
Formula1	-5.9	-15.9
Football2	-10.2	-13.2
Football3	-9.0	-10.4
Soccer1	-21.0	-22.3
Soccer3	-7.1	-16.7

SUBJECTIVE TEST

Methodology

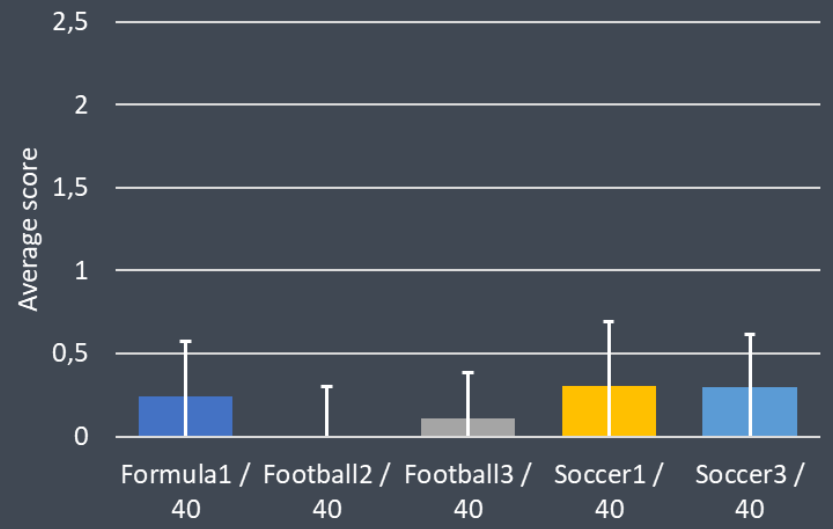
- Adjectival categorical judgement as described in BT.500-14
- A-B-A-B presentation
- Rating B versus A
- All parameters randomized
- **37 viewers**

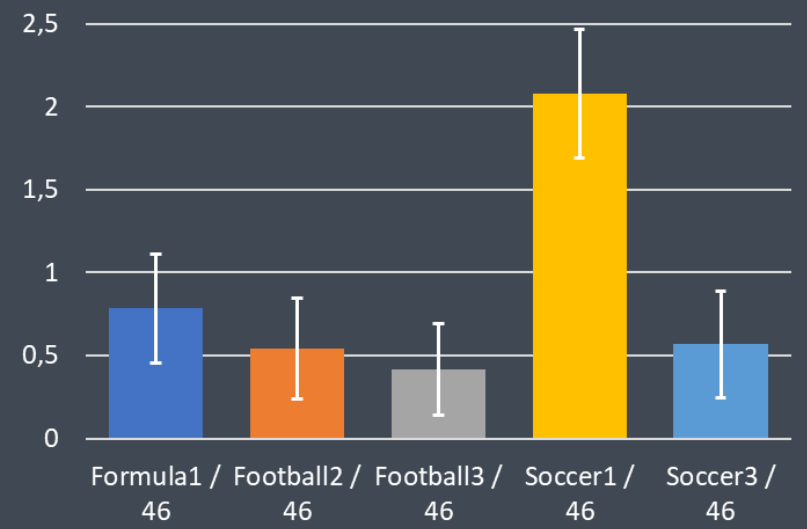
+3	Much better
+2	Better
+1	Slightly better
0	The same
-1	Slightly worse
-2	Worse
-3	Much worse

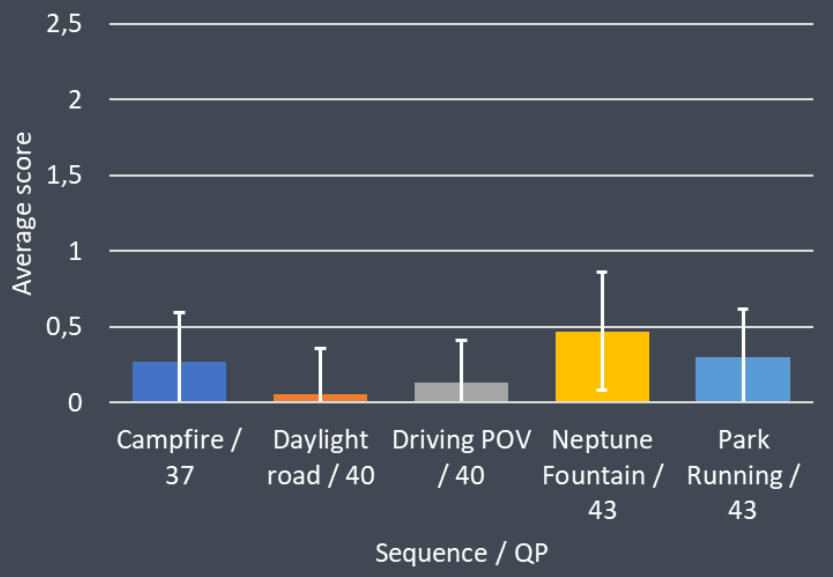
SUBJECTIVE PERFORMANCE

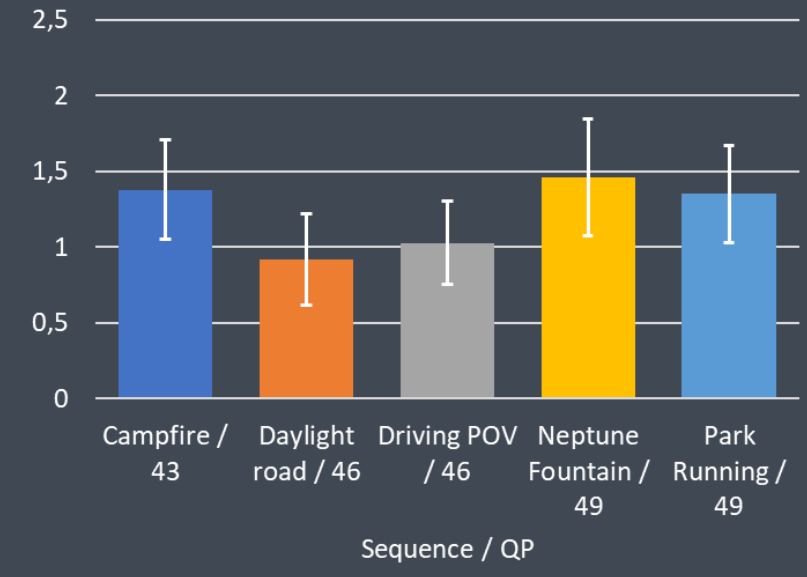
Standard test

- 19 / 20 positive
  - 1 / 20 equal
- 11 / 20 significantly better
  - 95% confidence interval
- The lower the bitrate, the more useful RPR is









SUBJECTIVE PERFORMANCE

Expert viewing

- Reaching the same conclusion: GOP based RPR control is beneficial
  - More stable quality percetion
  - Less compression artefacts
- No disruptions
  - Resolution change is visually seamless
- Fine overlay texts and logos get blurred at 1/2 resolution
  - This is expected
  - The overall feeling of quality remains better with RPR

04 Conclusion

RPR PERFORMANCE

- Objective performance
  - From -3.2% to -22.3% bitrate savings
- Subjective performance: standard test
  - GOP based RPR control is beneficial
  - No loss
    - Worst case is identical to regular single resolution encoding
- Subjective performance: expert viewing
  - Reaching the same conclusion
  - Resolution change is visually seamless

FUTURE WORKS

- Fine-tuning the PSNR thresholds
  - PSNR thresholds for reduced resolution relatively conservative
  - Room for further subjective improvements
- Deciding the resolution changes more often than every 32 frames
  - Or synchronizing the decision with an adaptive GOP strategy
- Extending the resize ratios
  - Covering a wider bitrate range starting from a single large resolution
  - Defining an OTT ladder as a set of bitrates only

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THANK YOU.