Investigating the Impact of High Frame Rates on Video Compression

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VILab Visual Information Laboratory

EPSRC

BBC R&D

Why higher frame rates?

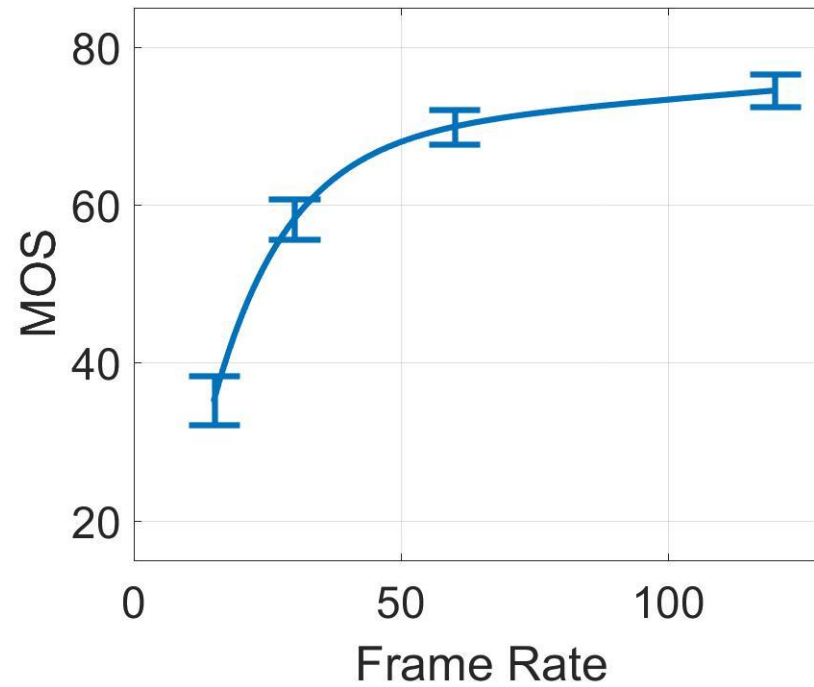❑ Clear reduction in the visibility of motion artefacts

15 fps   120 fps

The visibility of motion blur at (left) low and (right) high frame rates

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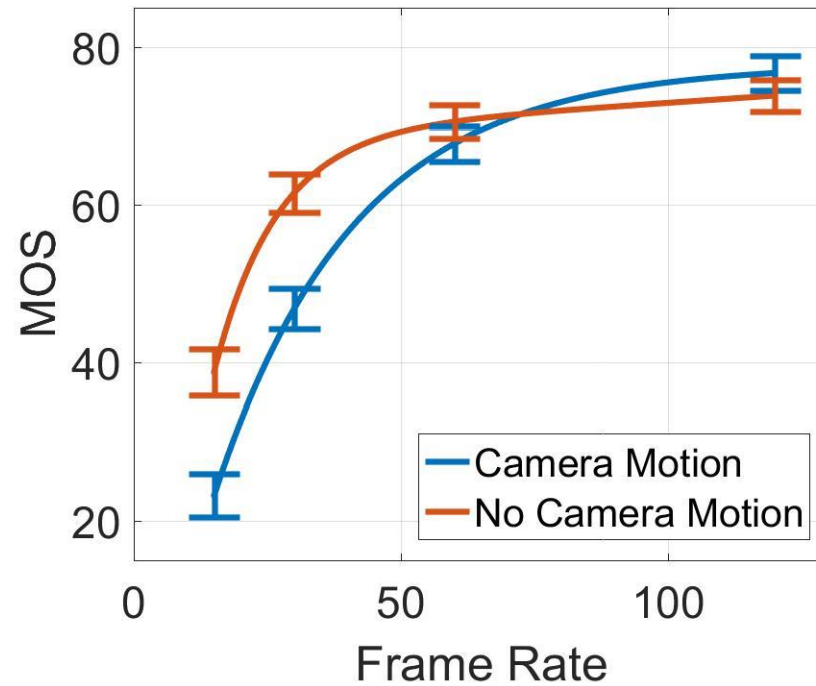
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❑ Increased video quality [1]

The relationship between perceptual quality (MOS) and frame rate for all the sequences in BVI-HFR

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❑ Increased video quality, although results show content dependence [1]

The impact of camera motion on the relationship between perceptual quality (MOS) and frame rate

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❑ Virtual Reality (VR)

Practical Considerations and Limitations of HFR

- ❑ Negative press e.g. The Hobbit
- ❑ Camera noise
- ❑ Production workflows
- ❑ Artificial lighting
- ❑ 'Suspension of disbelief' i.e. immersion
- ❑ Increased data rates

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Video Compression

❑ We need to ascertain whether the benefits of HFR content are preserved at current/proposed broadcast data rates
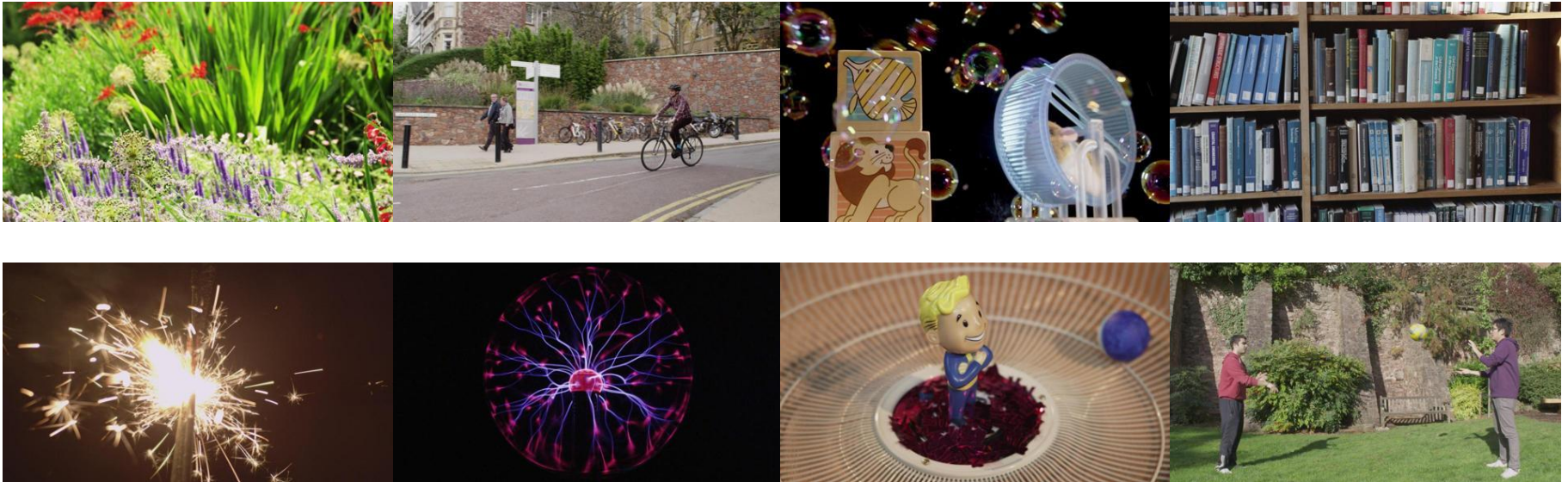
Video Compression

❑ We need to ascertain whether the benefits of HFR content are preserved at current/proposed broadcast data rates

❑ This can be achieved by investigating the rate-quality performance of the latest video compression standard HEVC for content that spans a range of frame rates

BVI-HFR Video Database

❑ 22 video sequences at 120 fps, HD, 8 bit, 360˚ shutter

❑ Spans a variety of colours, motions and scenes

❑ Publicly available

❑ Contains subjective evaluations (SSCQE) from large scale subjective experiment (51 participants)

❑ Lower frame rate versions can be generated using the averaging frames method of temporal down-sampling

BVI-HFR Video Database

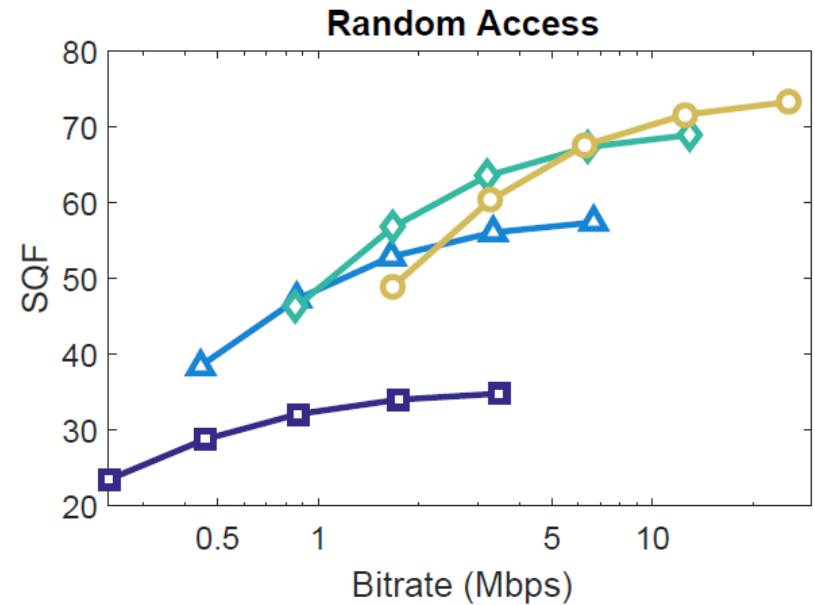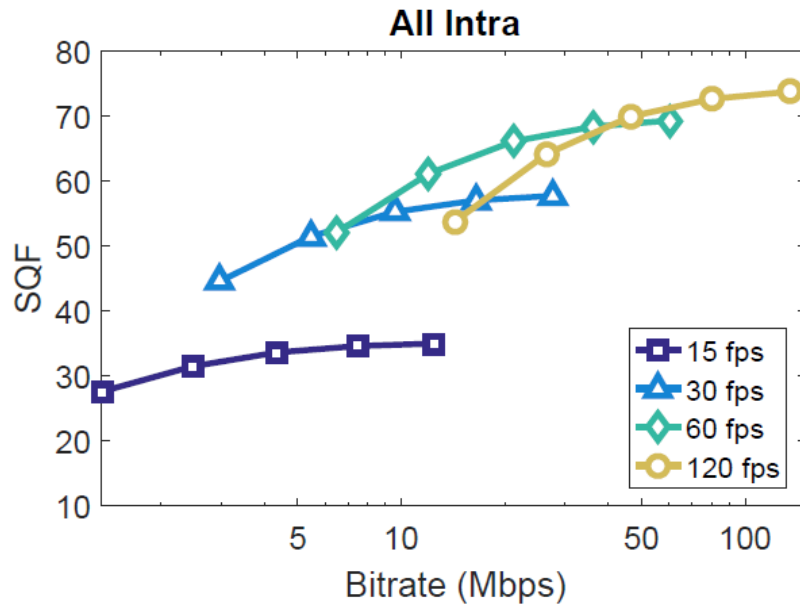*Sample frames from a selection of sequences from the BVI-HFR video database*

Methodology

Parameter	Value
Frame Rate	120, 60, 30, 15
QP	22, 27, 32, 37, 42
Compression Profiles	All Intra (AI), Low Delay (LD) and Random Access (RA)
HEVC Codec	HM 16.4

Degradation in video quality due to compression is estimated using SQF quality metric [4]

The influence of frame rate on rate-quality performance of HEVC

Rate-Quality Analysis

❏ Increased spatial complexity associated with high frame rates is more difficult to encode

❏ Motion prediction (LD, RA) dramatically decreases the number of bits consumed by the encoder (as may be expected!)
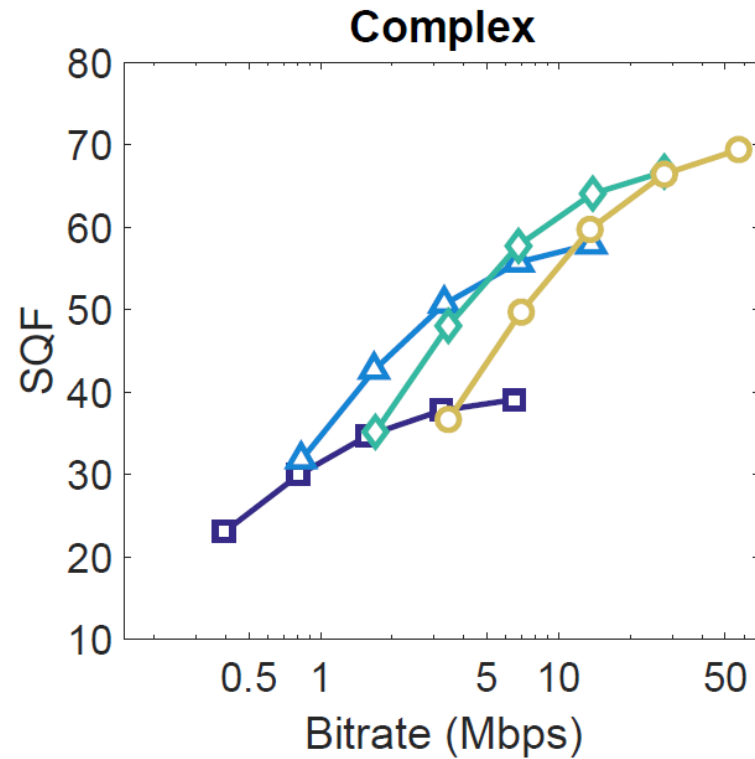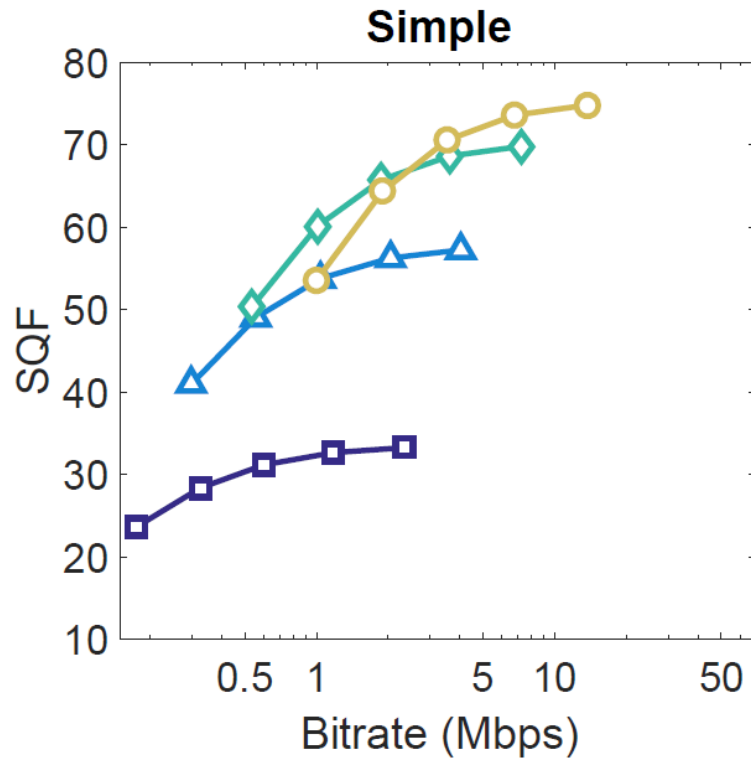
Optimal Frame Rates

❑ The Pareto frontier of the rate-quality curves can be used to calculate the optimal frame rate at a given bitrate

❑ A *transition* point is the bitrate at which the frame rate changes on the Pareto frontier
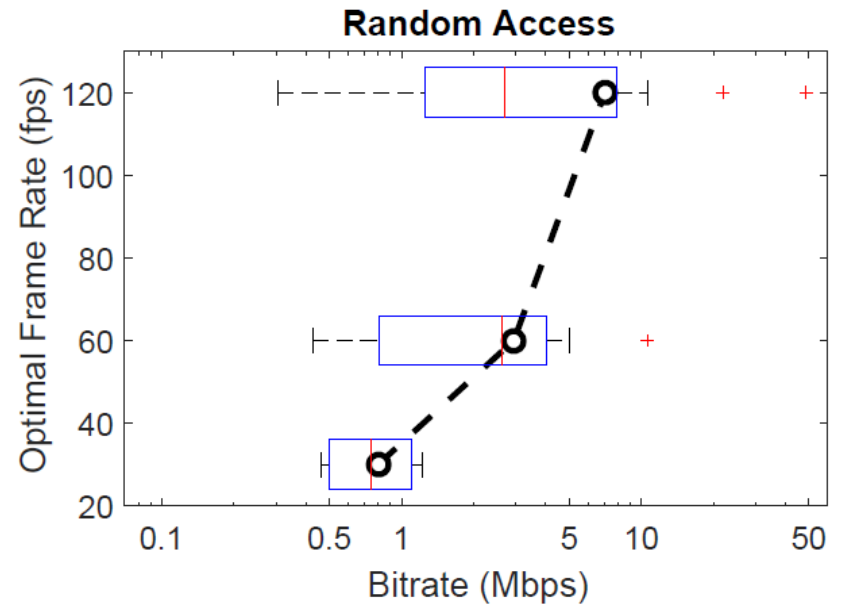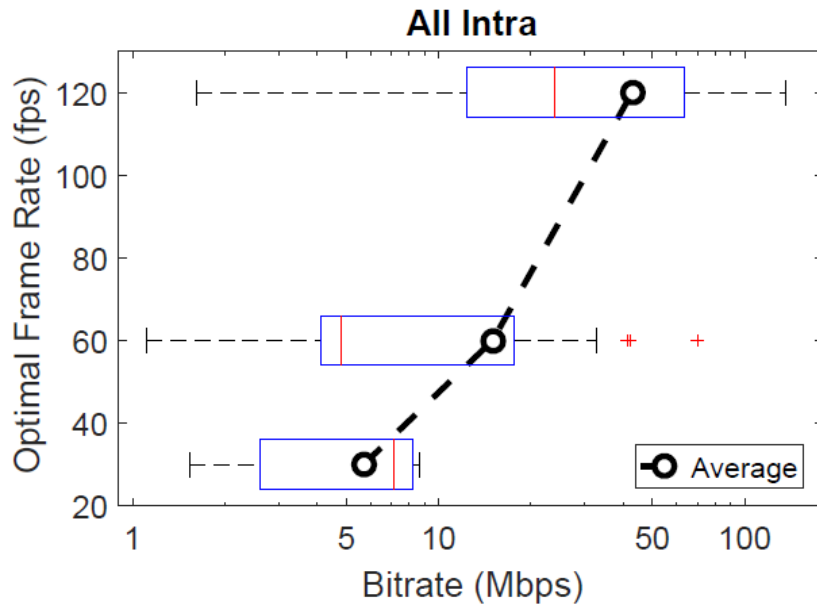
*Boxplots showing the distribution of transition points*

Content Dependence

❑ Rather than use a regression model (which is susceptible to over-fitting), we propose simply partitioning video sequences into the following groups to model content dependence:

➢ *simple or complex (displaced frame difference)*

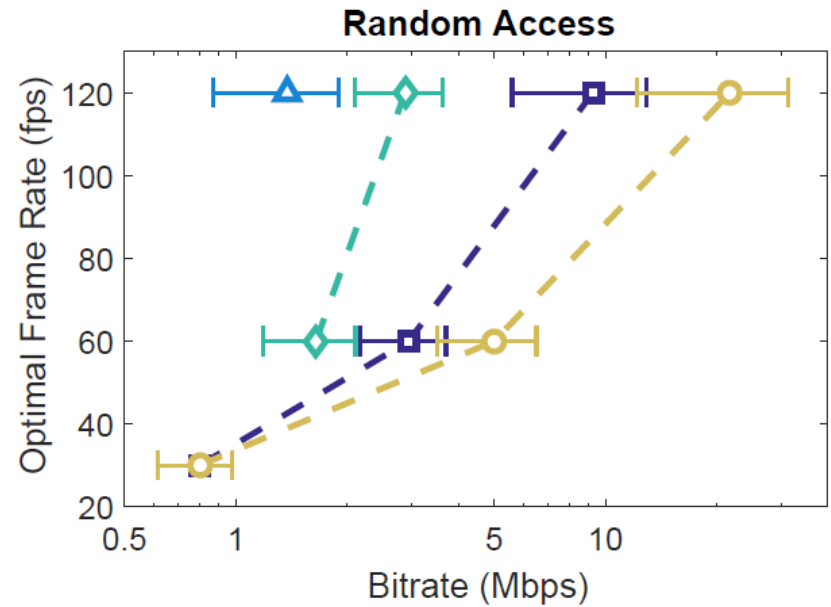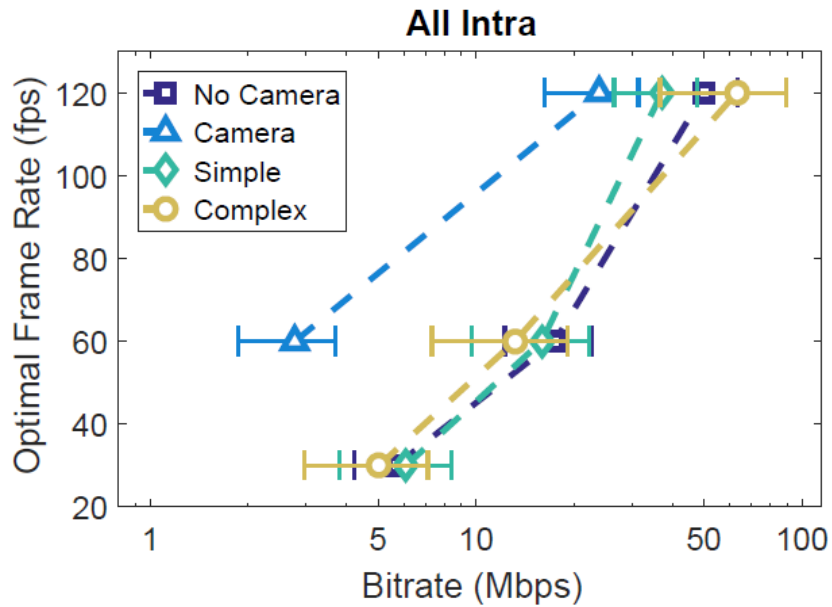➢ *camera or no camera motion (inspection)*

How content and frame rate affects the rate-quality performance of HEVC
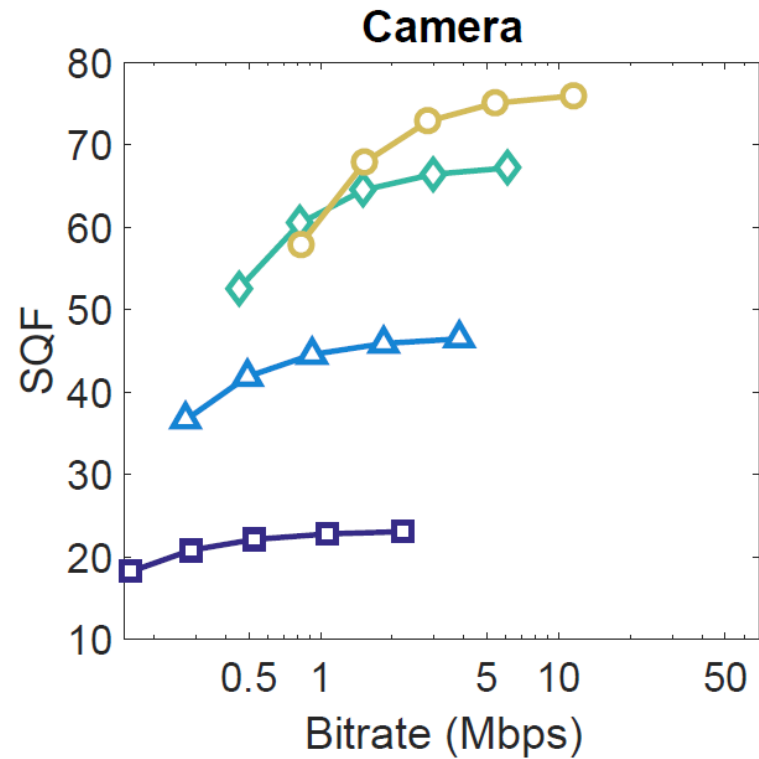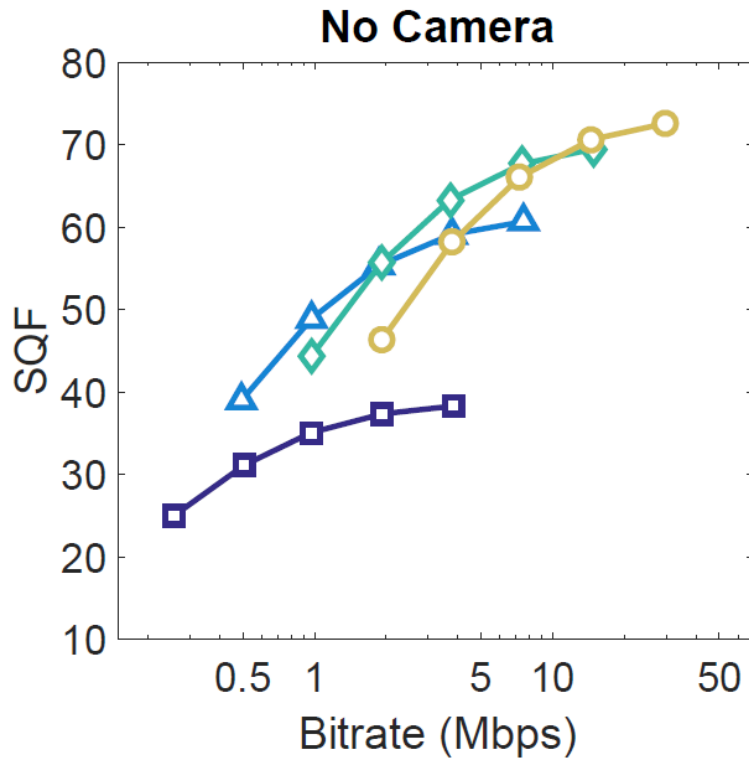
How content and frame rate affects the rate-quality performance of HEVC

How content and frame rate affects optimal frame rate selection

Frame Rate Predictions

❑ 60 and 120 fps are the optimal choices for frame rates at bitrates of 3 and 7 Mbps respectively

❑ 65% of sequences had an optimal frame rate of at least 60 fps at the bitrate recommended by Netflix [5] for streaming HD content (5 Mbps)

❑ All sequences with camera motion had an optimal frame rates of 120 fps at this bitrate

HEVC – Review

❑ Motion prediction utilises the increased temporal correlation between frames at higher frame rates to reduce bitrate

❑ HEVC needs to further exploit the increased spatial complexity (with reduced motion blur) at higher frame rates

❑ The poor performance of the HM encoder with respect to complex motion is postulated to be due to the use of linear motion models to characterise nuanced motion

Conclusions

❑ High frame rates (60 fps+) can provide clear perceptual benefits at current data rates

❑ The rate-quality performance of the HEVC encoder is content dependent, specifically related to motion

❑ The HEVC encoder could be improved through exploitation of the source statistics of higher frame rate material e.g. sharper edges, increased temporal correlation between frames

Funding/Support from:

References

[1] *A. Mackin, F. Zhang, and D. Bull, "A study of subjective video quality at various frame rates," in* Image Processing (ICIP), 2015 22nd IEEE International Conference on*, 2015*

[2] *L. Wilcox et al.*, "*Evidence that viewers prefer higher frame-rate film*," ACM Transactions on Applied Perception (TAP), vol. 12, no. 4, pp. 15, 2015

[3] *B. Tag et al., "In the eye of the beholder: The impact of frame rate on human eye blink," in* Human Factors in Computing Systems, 2016 CHI Conference on, 2016

[4] *Y. Ou et al., "Perceptual quality assessment of video considering both frame rate and quantization artifacts,"* Circuits and Systems for Video Technology, IEEE Transactions on, vol. 21, no. 3, pp. 286–298, 2011

[5] *Netflix, "[Internet connection speed recommendations](#)*"