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Fundamental relationships between subjective quality, user acceptance, and the VMAF metric for a quality-based bit rate ladder design for over-the-top video streaming services

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OUTLINE



- Introduction
- Quality-based bit rate ladder design
- Determination of the bit rate ladder parameters
- Conclusion

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OVER-THE-TOP VIDEO STREAMING SERVICES



- Video signals are encoded at various bit rates $R_1, ..., R_k, ..., R_K$ and associated qualities $Q_1, ..., Q_k, ..., Q_K$, denoted as bit rate ladder
- Encoded video signals are provided to various clients via the internet
- In the past: Encoding with predefined bit rates irrespective of video quality



- Problems:
 - Bit rates are higher than necessary for providing signals being indistinguishable from the original signals
- Bit rate R_K too low resulting in signals being significantly distinguishable from the original signals SPIE, August 2021

OVER-THE-TOP VIDEO STREAMING SERVICES



• Today:

Approaches are raising which more and more consider the quality of the provided video signals

• Main question:

Which qualities $Q_1, ..., Q_k, ..., Q_k$ need to be ideally provided maximizing subjective quality under the constraint of minimized storage costs

SIMPLE CLIENT MODEL



Bit rate selection for playout according to the transmission rate *T* of the client's internet connection:



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DETERMINATION OF BIT RATE LADDER PARAMETERS IN SUBJECTIVE TESTS



- Set up following ITU-R. Rec. BT.500
- Set of 8 video signals in 4K and HD resolution (6 from ISO / ITU, 2 proprietary)
- HEVC reference coder
- Random Access configuration
- Panasonic 4K OLED TV with 55" diagonal
- Distance: 2 x Height of active display
- 20 observers













DETERMINATION OF *VMAF_K*



Methodology:

- Double stimulus impairment scale
- 11-grade numerical scale

Result: $VMAF_K \ge 95$



DETERMINATION OF VMAF₁

- Considered range of VMAF scores: 20 95
- Asking observers for willingness to watch the videos at each considered VMAF score
- Four scenarios considered resulting from
 - Free / Paid streaming services
 - Permanent viewing / temporary impairment
- Calculation of acceptance rates AR



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DETERMINATION OF $\Delta VMAF_{max}$



Methodology:

- Double stimulus impairment scale
- 11-grade numerical scale

Results:

- For $\Delta VMAF_{max} \ge 3$: Confidence intervals do not always overlap
- For $\Delta VMAF_{max} \leq 2$: Confidence intervals always overlap

 $\Rightarrow \Delta VMAF_{max} \leq 2$



IDEAL BIT RATE LADDER



Properties:

- Maximizing subjective quality under the constraint of minimized storage costs
- $VMAF_1 = 55$, $VMAF_K = 95$, $\Delta VMAF_{max} = 2$
- Providing 21 qualities according to the VMAF scores 55, 57, ..., 93, 95

Implications:

- To exactly reach the VMAF scores, large encoding effort is typically necessary
- To reduce the encoding effort, parameters $VMAF_K > 95$, or $\Delta VMAF_{max} < 2$ may be accepted while generating the bit rate ladder
- However, this increases the number of provided qualities beyond 21 and thus the storage costs

CONCLUSION



- A quality-based bit rate ladder design for over-the-top video streaming services is presented
- Bit rate ladder parameters determined in extensive subjective tests
- Ideal bit rate ladder provides 21 qualities with the VMAF scores 55, 57, ..., 93, 95 in order to maximize the subjective quality under the constraint of minimized storage costs
- Using more than 21 qualities can compromise encoding and storage costs
- Applications using fewer than these 21 qualities may suffer from impaired subjective quality



THANK YOU FOR YOUR ATTENTION

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