



HAL
open science

Elevating Your Streaming Experience with Just Noticeable Difference (JND)-based Encoding

Jingwen Zhu, Hadi Amirpour, Vignesh V Menon, Raimund Schatz, Patrick Le Callet

► **To cite this version:**

Jingwen Zhu, Hadi Amirpour, Vignesh V Menon, Raimund Schatz, Patrick Le Callet. Elevating Your Streaming Experience with Just Noticeable Difference (JND)-based Encoding. ACM MILE-HIGH VIDEO 2023, May 2023, Denver, United States. 10.1145/3588444.3591025 . hal-04086578

HAL Id: hal-04086578

<https://hal.science/hal-04086578v1>

Submitted on 2 May 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Elevating Your Streaming Experience with Just Noticeable Difference (JND)-based Encoding

Jingwen Zhu¹, Hadi Amirpour², Vignesh V Menon², Raimund Schatz³, Patrick Le Callet¹

¹Nantes Universite, Ecole Centrale Nantes, CAPACITES SAS, CNRS, LS2N, UMR 6004, F-44000 Nantes, France

²Christian Doppler Laboratory ATHENA, Alpen-Adria-Universität, Klagenfurt, Austria

³AIT Austrian Institute of Technology, Austria

ABSTRACT

With the growing number of video streaming applications, intelligent video streaming has become increasingly important. By considering JND, video delivery can be improved by avoiding the selection of encodings with similar quality for a bitrate ladder. In this paper, we present an overview of the existing methods for modeling and predicting JND in the context of video streaming applications.

CCS CONCEPTS

• Information systems → Multimedia streaming.

KEYWORDS

Just Noticeable Difference (JND), Satisfied User Ratio (SUR)

ACM Reference Format:

Jingwen Zhu¹, Hadi Amirpour², Vignesh V Menon², Raimund Schatz³, Patrick Le Callet¹. 2023. Elevating Your Streaming Experience with Just Noticeable Difference (JND)-based Encoding. In *Mile-High Video Conference (MHV '23)*, May 7–10, 2023, Denver, CO, USA. ACM, New York, NY, USA, 2 pages. <https://doi.org/10.1145/3588444.3591025>

1 OVERVIEW AND RESULTS

We currently witness the rapidly growing importance of intelligent video streaming quality optimization and reduction of video delivery costs [4, 5]. One area that is of critical importance in optimizing video streaming is finding the optimal bitrate ladder. A bitrate ladder is composed of multiple versions of the same video, each encoded at different bitrates and resolutions. By providing multiple versions of the video, the adaptive bitrate streaming technology allows clients to select the most appropriate version of the video that matches their network conditions and device type. This ensures a seamless and uninterrupted viewing experience for the client, even if their internet speed fluctuates. A fixed bitrate ladder, *i.e.*, a fixed set of bitrate-resolution pairs, was typically used for all video contents regardless of their characteristics. Per-title encoding [1, 3], in contrast to a fixed bitrate ladder, shows significant promise to deliver higher quality video streams by addressing the trade-off between compression efficiency and video characteristics

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

MHV '23, May 7–10, 2023, Denver, CO, USA

© 2023 Copyright held by the owner/author(s). Publication rights licensed to ACM.

ACM ISBN 979-8-4007-0160-3/23/05...\$15.00

<https://doi.org/10.1145/3588444.3591025>

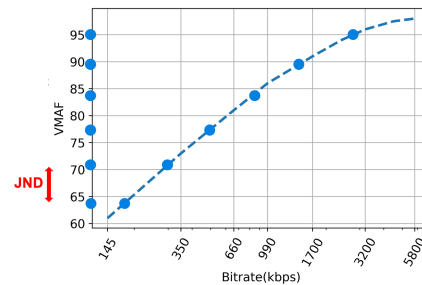


Figure 1: JND-based bitrate ladder construction

such as resolution and frame rate. Selecting encodings with noticeable quality differences in between prevents the construction of an inefficient bitrate ladder that suffers from having similar quality representations [6] (see Figure 1). The Human Visual System (HVS) is capable of differentiating only a few discrete levels of distortion in compressed videos over a wide range of bitrates, as demonstrated in [8]. The minimum visual difference that can be perceived by HVS, *i.e.*, the difference between two adjacent perceptual distortion levels, is referred to as one Just Noticeable Difference (JND)[7]. The first JND point denotes the transitional point from perceptually lossless to perceptually lossy coding. By selecting encodings with one JND between them, an optimized bitrate ladder can be achieved, as this prevents the inclusion of encodings with similar quality. Satisfied-User-Ratio (SUR) curve has been widely used for JND modeling and prediction. It is the complementary cumulative distribution function of the individual JNDs of a group of viewers. One JND occurs when a certain percentage of users can perceive a difference in quality between two videos.

In this talk, we explore ways to optimize the JND subjective test methodology and the mathematical modeling of SUR curves from the subjective JND test data in the context of video compression. Additionally, we predict JND values using proxies such as Video Multimethod Assessment Fusion (VMAF) [2, 10] and Quantization Parameter (QP) [9] with machine learning methods. The experimental results indicate that Gaussian distribution is not the optimal choice for modeling the satisfied-user-ratio (SUR) curve. Moreover, predicting the optimal parameters for SUR modeling instead of individual points on the curve results in higher accuracy and less complexity. Finally, using the publicly available JND dataset VideoSet [8], we demonstrate the optimization of the JND search method based on binary search [8] and evaluate the performance of prediction models for both SUR and JND [11]. We would like to highlight that for streaming optimization, different proxies such as VMAF, quantization parameter (QP), and bitrates can be utilized for different use cases.

2 ACKNOWLEDGE

We would like to express our sincere gratitude to Amazon Prime, Capacités, and Christian Doppler Laboratory ATHENA for their sponsorship. We would also like to thank the anonymous participants who generously contributed their time and efforts to provide us with valuable data.

REFERENCES

- [1] Hadi Amirpour, Mohammad Ghanbari, and Christian Timmerer. 2022. Deep-Stream: Video Streaming Enhancements using Compressed Deep Neural Networks. *IEEE Transactions on Circuits and Systems for Video Technology* (2022), 1–1. <https://doi.org/10.1109/TCSVT.2022.3229079>
- [2] Hadi Amirpour, Raimund Schatz, and Christian Timmerer. 2022. Between Two and Six? Towards Correct Estimation of JND Step Sizes for VMAF-based Bitrade Laddering. In *2022 14th International Conference on Quality of Multimedia Experience (QoMEX)*. IEEE, 1–4.
- [3] Jan De Cock, Zhi Li, Megha Manohara, and Anne Aaron. 2016. Complexity-based consistent-quality encoding in the cloud. In *2016 IEEE International Conference on Image Processing (ICIP)*. 1484–1488. <https://doi.org/10.1109/ICIP.2016.7532605>
- [4] Alireza Erfanian, Hadi Amirpour, Farzad Tashtarian, Christian Timmerer, and Hermann Hellwagner. 2021. LwTE: Light-Weight Transcoding at the Edge. *IEEE Access* 9 (2021), 112276–112289. <https://doi.org/10.1109/ACCESS.2021.3102633>
- [5] Alireza Erfanian, Hadi Amirpour, Farzad Tashtarian, Christian Timmerer, and Hermann Hellwagner. 2021. LwTE-Live: Light-Weight Transcoding at the Edge for Live Streaming. In *Proceedings of the Workshop on Design, Deployment, and Evaluation of Network-Assisted Video Streaming (Virtual Event, Germany) (Vis-NEXT'21)*. Association for Computing Machinery, New York, NY, USA, 22–28. <https://doi.org/10.1145/3488662.3493829>
- [6] Vignesh V Menon, Hadi Amirpour, Mohammad Ghanbari, and Christian Timmerer. 2022. Perceptually-Aware Per-Title Encoding for Adaptive Video Streaming. In *2022 IEEE International Conference on Multimedia and Expo (ICME)*. 1–6. <https://doi.org/10.1109/ICME52920.2022.9859744>
- [7] Haiqiang Wang, Ioannis Katsavounidis, Qin Huang, Xin Zhou, and C-C Jay Kuo. 2018. Prediction of satisfied user ratio for compressed video. In *2018 IEEE international conference on acoustics, speech and signal processing (ICASSP)*. IEEE, 6747–6751.
- [8] Haiqiang Wang, Ioannis Katsavounidis, Jiantong Zhou, Jeonghoon Park, Shawmin Lei, Xin Zhou, Man-On Pun, Xin Jin, Ronggang Wang, Xu Wang, et al. 2017. VideoSet: A large-scale compressed video quality dataset based on JND measurement. *Journal of Visual Communication and Image Representation* 46 (2017), 292–302.
- [9] Jingwen Zhu, Patrick Le Callet, Anne-Flore Perrin, Sriram Sethuraman, and Kumar Rahul. 2022. On the benefit of parameter-driven approaches for the modeling and the prediction of satisfied user ratio for compressed video. In *2022 IEEE International Conference on Image Processing (ICIP)*. IEEE, 4213–4217.
- [10] Jingwen Zhu, Suiyi Ling, Yoann Baveye, and Patrick Le Callet. 2022. A framework to map vmaf with the probability of just noticeable difference between video encoding recipes. In *2022 IEEE 14th Image, Video, and Multidimensional Signal Processing Workshop (IVMSP)*. IEEE, 1–5.
- [11] Jingwen Zhu, Anne-Flore Perrin, and Patrick Le Callet. 2022. Subjective test methodology optimization and prediction framework for Just Noticeable Difference and Satisfied User Ratio for compressed HD video. In *2022 Picture Coding Symposium (PCS)*. IEEE, 313–317.