Video Quality Sufficiency for Sustainable Video Streaming

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***Abstract*—With the effects of climate change globally manifesting, all sectors of the economy and society are aiming to reduce their carbon emissions. For the ICT sector the concept of sufficiency has been proposed as a paradigm to go beyond efficiency improvements towards an absolute reduction of carbon emissions. Yet little is known about the practical implementation of sufficiency and its carbon reduction potential. We are providing a concrete example of the user sufficiency sub-category by considering the quality-energy curves, in order to make trade-offs between user experience and energy consumption measurable and actionable, and allowing to quantify the carbon reduction potential from this intervention.**

***Index Terms*—QoE, Sufficiency, Sustainability, Video Streaming, Energy.**

I. Extended Abstract

Growing attention is been given to the carbon footprint of video streaming. Innovation and optimisation of video codecs can affect the energy consumption in all system parts. Previous research [1]–[3] has identified potential solutions to increase energy efficiency, yet methods to reliably estimate the long-term carbon reduction potential from interventions on the video streaming pipeline are currently lacking [4]. While technical solutions can increase the efficiency of services, they are embedded and constrained by boundaries set within a socio-technical context. In response, the concept of Sufficiency has been proposed to refer to strategies that directly aim for absolute impact reductions from lowering production and consumption [5]. While sufficiency and, related to this, sobriety are increasingly advocated, their actual potential to affect meaningful carbon reduction has not been explored.

User sufficiency in video quality refers to satisfying user quality (objective) needs or (subjective) expectations with the lowest use of resources in shared infrastructure (datacentres and networks) and on user devices. Quality of experience is also further constrained by technical capabilities. For example, users with low bandwidth network (e.g. less than 2Mbps) or older screens (less than FHD resolution displays) might be limited and expect VMAF [6] scores between 70-80. While a user with a 4K TV and fibre broadband is able (and expect) VMAF scores of 90 and higher. Furthermore, the quality-energy relation is content-dependent and is not always aligned with the quality-rate curve. This is illustrated in the example quality-rate and quality-energy curves of Fig. 1.

We suggest exploring the use of the quality-energy curve towards greater user sufficiency. It can be straightforwardly used to drive adaptive bitrate streaming. This means that content-gnostic adaptive bitrate streaming ladders constructed by sampling the quality-rate Pareto front (e.g. see [7]) need to be re-designed by taking into account the quality-energy trade-offs. It also enables estimating the absolute carbon reduction potential from quality constraints [4]. Finally, the Pareto-curve can be used to guide the implementation of user sufficiency in design. For example, behaviour change might be supported by allowing users to chose desired quality levels for varying consumption contexts, and provide information on carbon savings alongside such choice. In our future work, we explore this dimension and propose a framework that takes into account the quality-rate curve characteristics for an end-to-end optimisation.

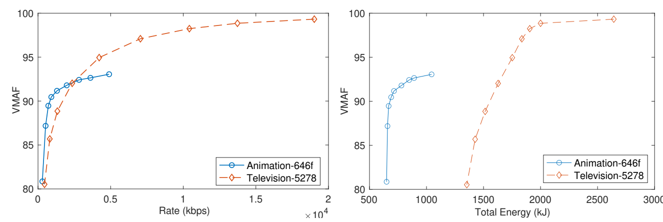

Fig. 1. Examples of VMAF-Rate and VMAF-Energy curves using SVT-AV1. These examples demonstrate a different quality-energy tradeoff that cannot be directly aligned with the VMAF-Rate tradeoff. Both sequences are FHD, with 30fps framerate for Animation-646f and 25fps for Television-5278.

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