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Title	**[GSC] Temporal smoothing of opacity attribute in video-based GSC**
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1. Abstract

We introduce a preprocessing pass for 3D Gaussian Splatting Coding in a video-based GSC, where attribute values are represented as image sequences. We identify splats with minimal spatial displacement across a Group of Pictures (GOP) and replace their per-frame opacity with the GOP average.

2. Introduction

In video-based GSC, the Gaussian splat cloud is created from multiple viewpoints around the scene. Each splat's opacity attribute derives from contributions across input views, making it sensitive to sensor noise, view misalignment, and quantization errors. These factors cause frame-to-frame opacity changes that appears as flicker in static regions. We assume this jitter primarily arises from sensor noise

To address this, we tested a preprocessing step that smooths opacity attributes across all frames in a GOP. In GSCodec Studio, we enabled smoothing before the PLAS sorting. By averaging the opacity attribute for splats with small spatial displacement, the method reduces flickering in the opacity sequence.

3. Proposed method

Let GOP contain N frames and S splats per frame. For each splat index s:

3.1. Displacement measurement

Compute per-axis extremes over the GOP:

$$\Delta X_s = \max_{f=1..N} X_{f,s} - \min_{f=1..N} X_{f,s}$$

$$\Delta Y_s = \max_{f=1..N} Y_{f,s} - \min_{f=1..N} Y_{f,s}$$

$$\Delta Z_s = \max_{f=1..N} Z_{f,s} - \min_{f=1..N} Z_{f,s}$$

Normalize by global ranges $R_i = AttrMaxGOP_i - AttrMinGOP_i$, then compute total displacement ratio:

$$R_s = \frac{\Delta X_s}{R_X} + \frac{\Delta Y_s}{R_Y} + \frac{\Delta Z_s}{R_Z}$$

3.2. Static splat selection

If $R_s \leq T$ where T is a threshold (e.g., 0.001) splat s is classified as static, otherwise dynamic.

3.3. Opacity smoothing

For each static splat s, compute the mean opacity:

$$\overline{\alpha_s} = \frac{1}{N}\sum_{f=1}^{N} \alpha_{f,s}$$

4. Experimental results

We evaluated the preprocessing smoothing on a 16-frame *'bartender'* sequence using two test views (v09, v11). When comparing the raw (Fig. 1) and smoothed (Fig. 2) opacity maps, a noticeable pixel-wise difference can be observed. The smoothed-opacity sequence consistently yielded smaller compressed file sizes, demonstrating an overall bitrate reduction. As expected, the objective quality assessment revealed some degradation, which depends on threshold when selecting static splats. (Fig. 3, 4, 5).

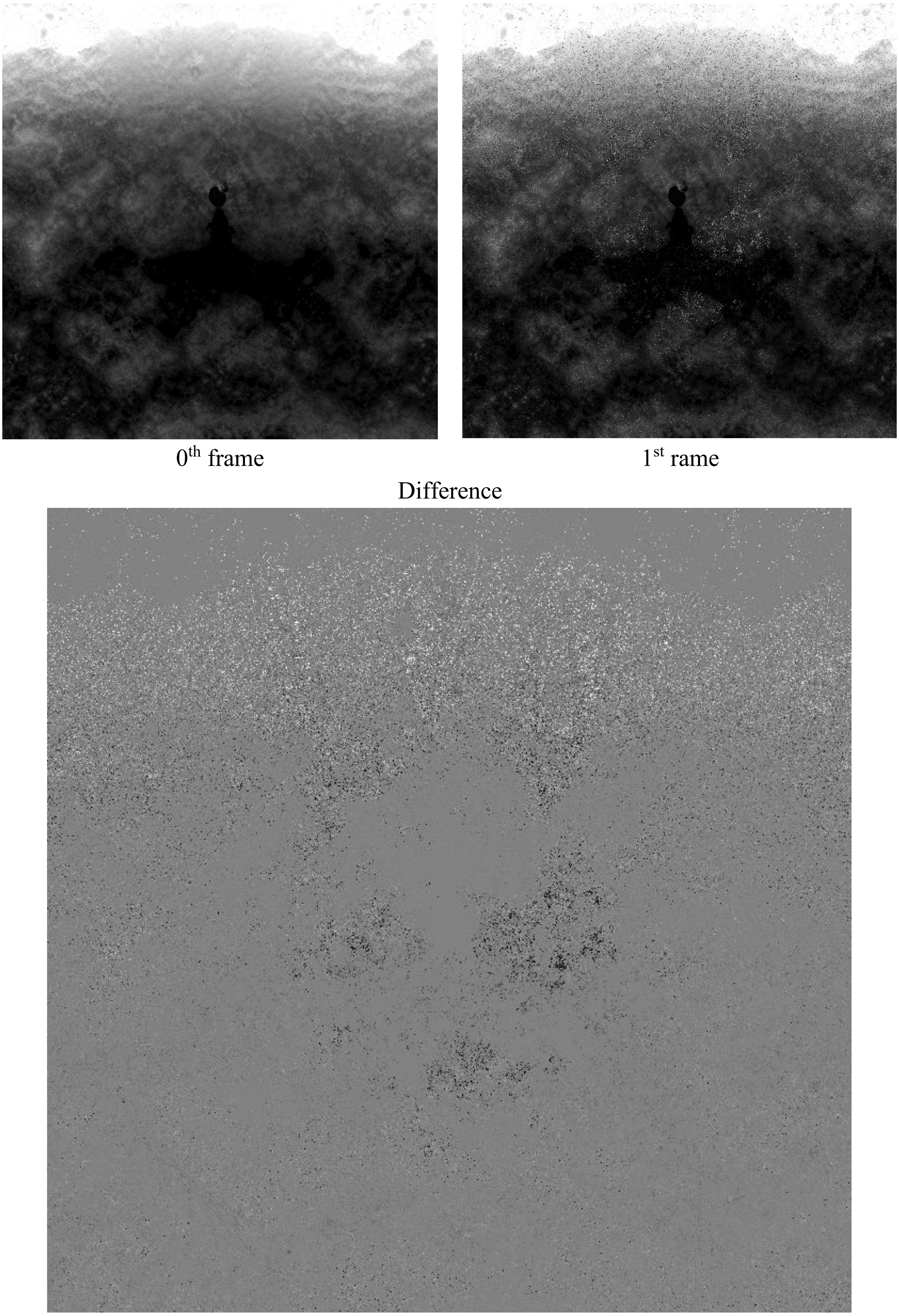

Fig. 1. Visible opacity values changes between two consequtive frames.

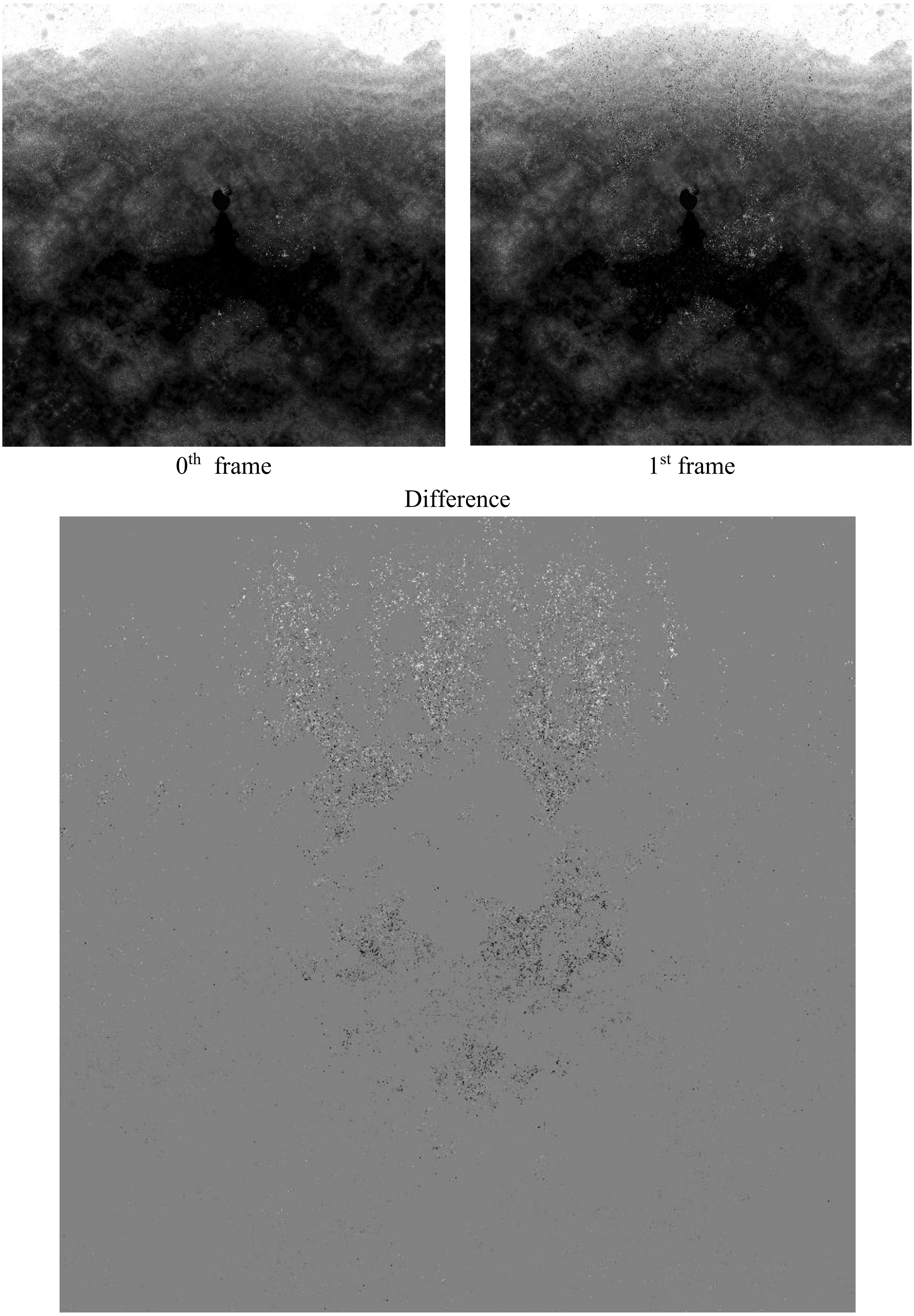

Fig. 2. Applying temporal opacity smoothing results in less sample changes across frames

RGB-PSNR
BD-rate: -3.8%,
BD-PSNR: 0.2%

YUV-PSNR
BD-rate: -3.7%,
BD-PSNR: 0.2%

YUV-SSIM
BD-rate: -5.5%,
BD-PSNR: 0.1%

YUV-IVSSIM
BD-rate: -6.4%,
BD-PSNR: 0.0%

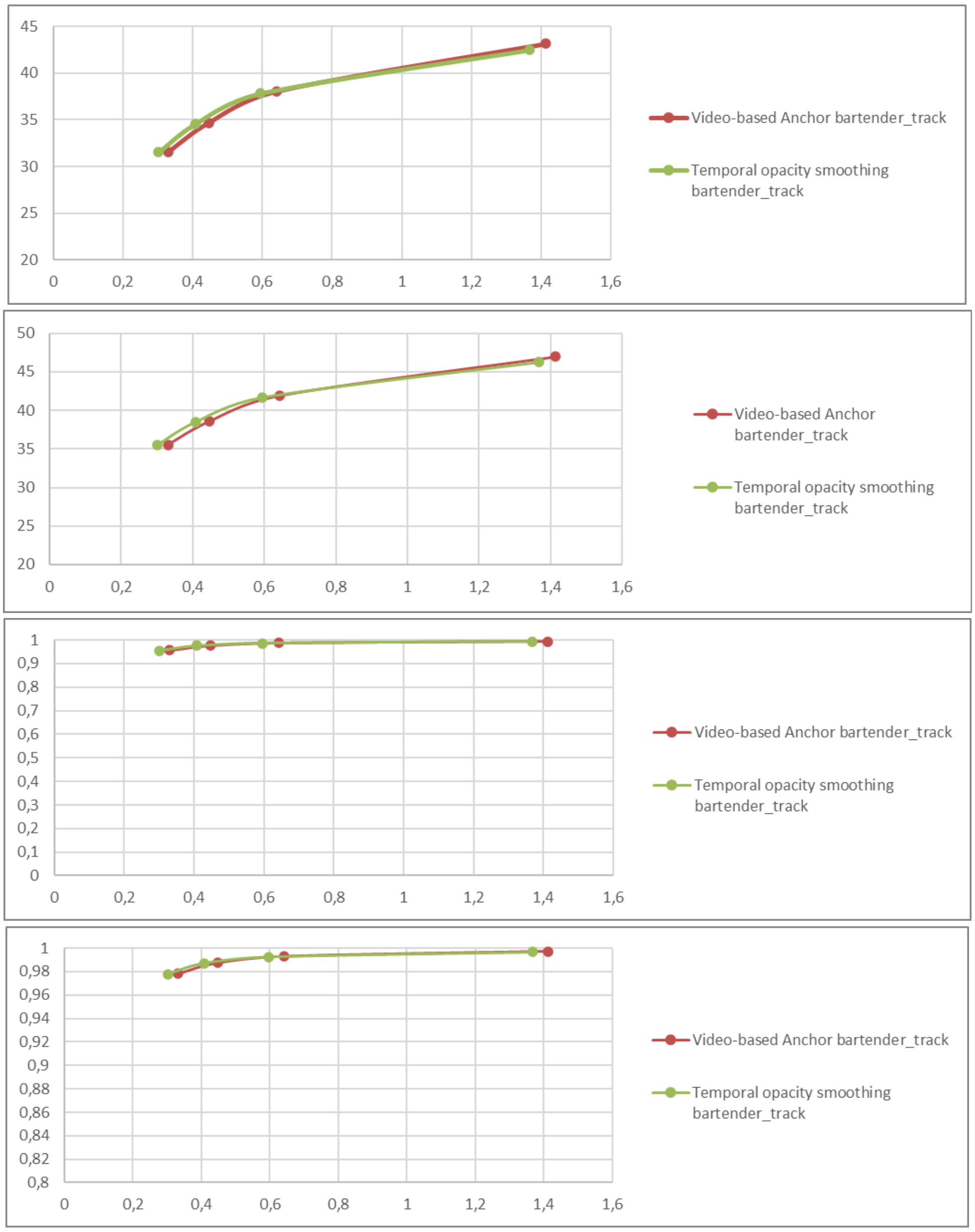

Fig. 3. Objective quality results (GSCodec Studio video anchor vs. +temporal opacity smoothing with suggested **0.001** threshold).

RGB-PSNR
BD-rate: 9.9%,
BD-PSNR: -5.0%

YUV-PSNR
BD-rate: -9.3%,
BD-PSNR: -4.1%

YUV-SSIM
BD-rate: -2.4%,
BD-PSNR: -0.1%

YUV-IVSSIM
BD-rate: -2.0%,
BD-PSNR: -0.1%

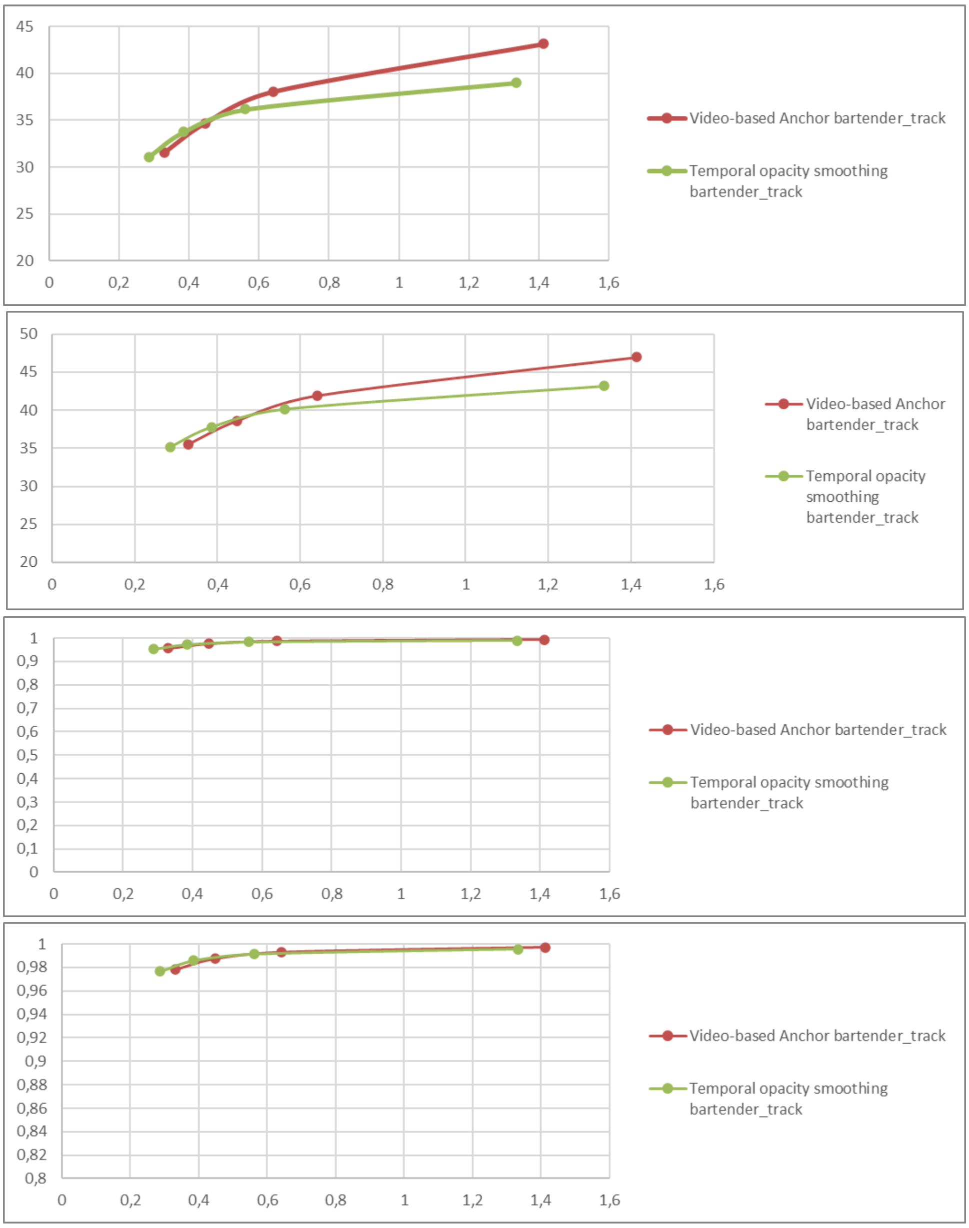

Fig. 4. Objective quality results (GSCodec Studio video anchor vs. +temporal opacity smoothing with **0.005 (5x higher)** threshold).

RGB-PSNR
BD-rate: 0.2%,
BD-PSNR: -0.1%

YUV-PSNR
BD-rate: 0.3%,
BD-PSNR: -0.1%

YUV-SSIM
BD-rate: 0.0%,
BD-PSNR: 0.0%

YUV-IVSSIM
BD-rate: -0.2%,
BD-PSNR: 0.0%

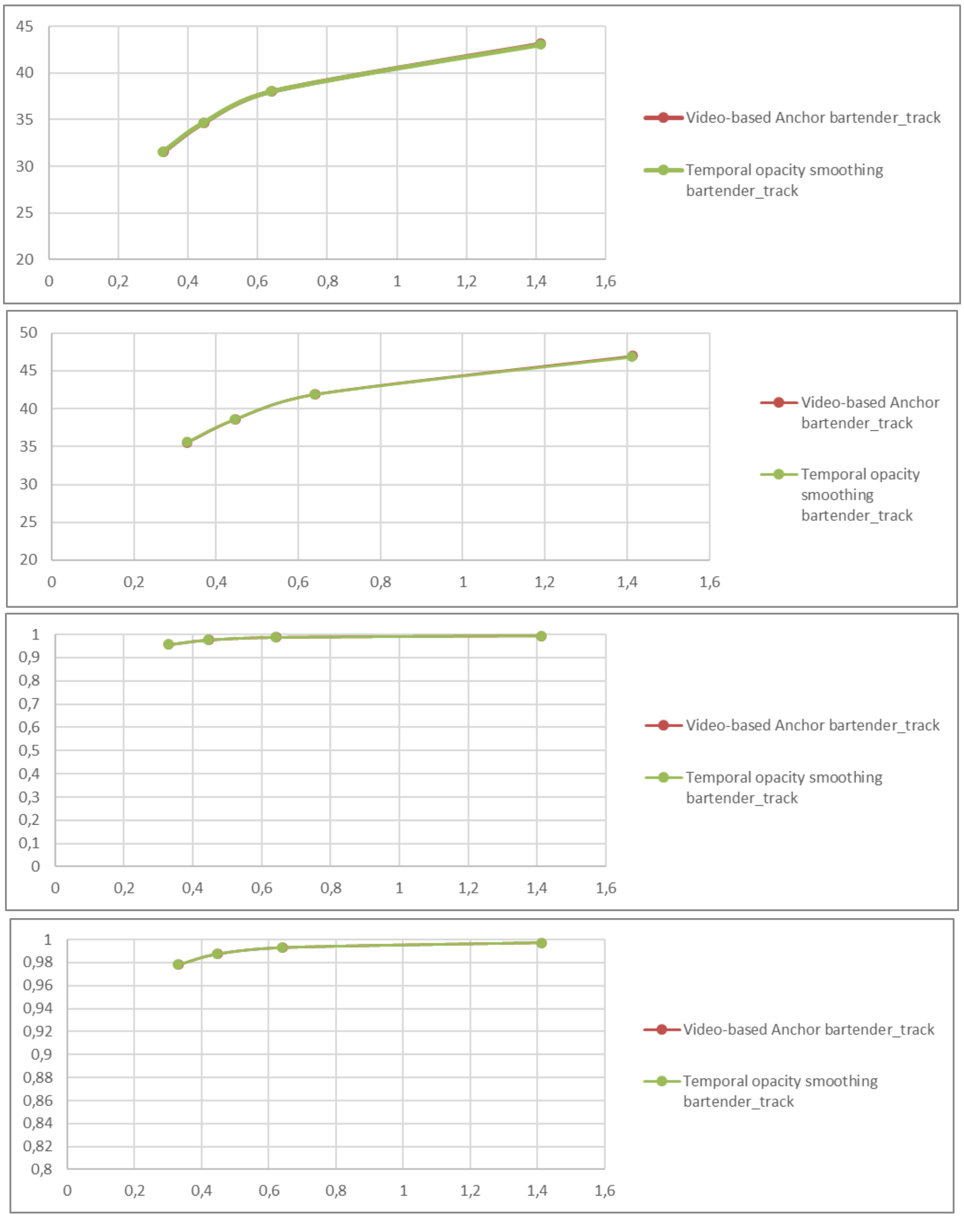

Fig. 5. Objective quality results (GSCodec Studio video anchor vs. +temporal opacity smoothing with **0.0002 (5x lower)** threshold).

Anchor

+Temporal opacity smoothing (thresh: **0.001**)

Rp0

Rp2

Fig. 6. Rendered test view v09 (8th frame).

5. Conclusion

The opacity smoothing reduces flickering in opacity attribute sequence and reduces bitrate size when encoding opacity maps with x265.

6. Recommendations

We recommend to explore the approach of temporal opacity smoothing further.

7. Acknowledgment

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