Improving quality of Anti-Aliasing (AA) in VR

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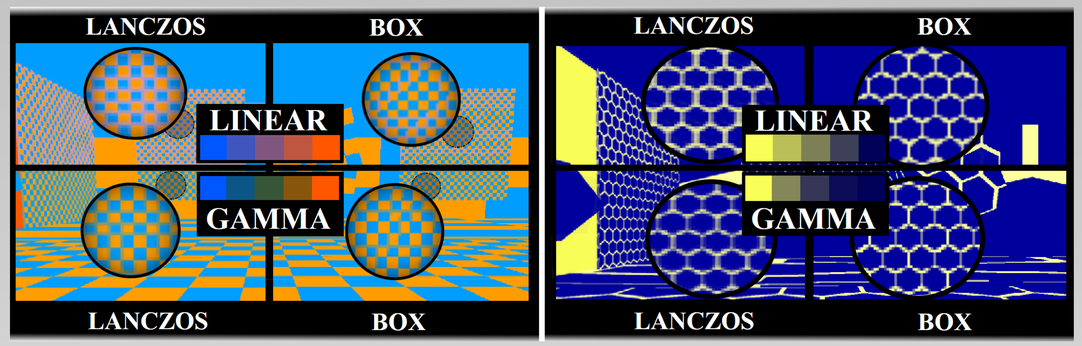
Motivation

- When compared to standard displays, Virtual Reality (VR) headsets offer much lower resolution. This can result in aliasing artifacts, which effectively reduce the quality of the immersive experience.
- **Regardless of the AA technique used, the quality of a rendered scene could be affected by the color space, in which it is performed.**
- Currently, there is no clear consensus on which color space should be used, with AA performed predominantly in a gamma-corrected space (sRGB) [LOT09].

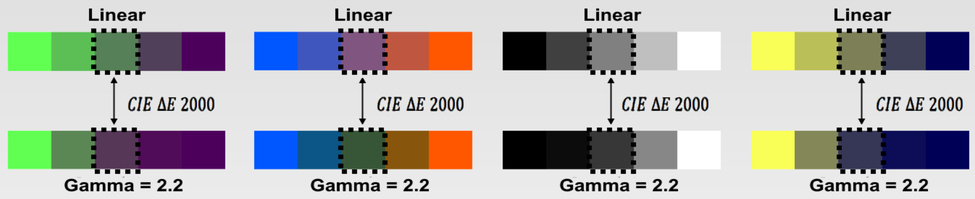
Aim

- In this work, we run a psychometric experiment to evaluate the quality of AA in VR performed in: **a linear** or **a gamma-corrected** space, using either an inexpensive **box filter**, or an accurate but expensive **Lanczos filter**.
- **Our hypothesis is that a significant improvement in quality can be achieved when AA is performed in linear color space, regardless of the type of filter used.**
- This could be due to the fact that the averaging in **linear space** more closely approximates the loss of resolution caused by the optical factors in the eye: aberration and scattering of the light in the lens, aqueous humour, vitreous body and on the retina.

Method



- Our stimuli consisted of two scenes with different procedurally-generated patterns: **checkerboard** and **honeycomb**.
- Four color pairs used to generate the patterns were chosen to maximize the *CIE ΔE 2000 distance* [SWD05] between the results of AA performed in **linear** and in **gamma-corrected** space:



- We compared the following four techniques:
  - **Box filter** in **linear RGB**
  - **Box filter** in **sRGB**
  - **Lanczos** in **linear RGB**
  - **Lanczos** in **sRGB**

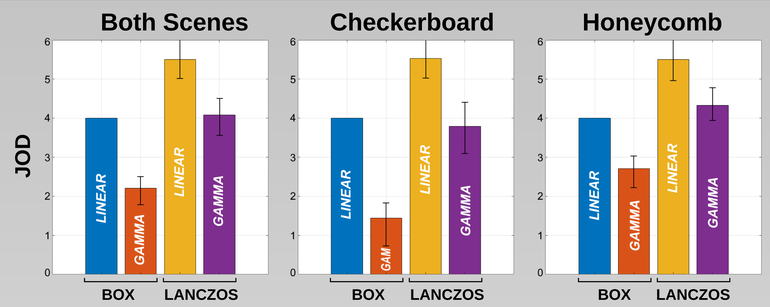
Rendering Algorithm

The scene was rendered to the buffer two times of the target's size, then downsampled to target's resolution using one of the four methods.

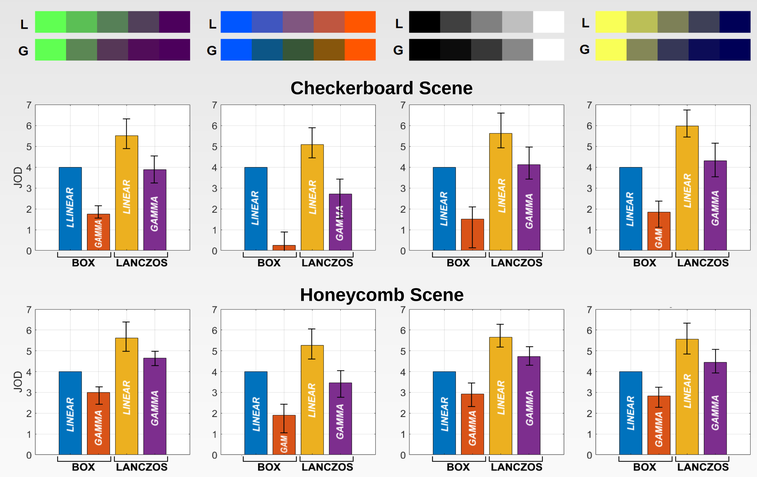
For **AA in linear RGB** downsampling was performed before applying gamma correction:

For **AA in gamma space**, gamma correction was performed first, followed by downsampling:

Results



- The results of the experiment were scaled under *Thurstone Model V* assumptions in just-objectionable differences (**JODs**) [POM17].
- **A significant improvement in quality was observed when AA is performed in the linear RGB and when better low-pass filter is used,** regardless of the scene. Kendall's *W* revealed **a significant agreement among participants** in ranking of the four techniques ($W = 0.90$, $p < .001$).



- The results were fairly consistent across all color pairs, with AA computed in **linear RGB** outperforming **sRGB** for each filter type.

References

[Lot09] LOTTES T.: Fast approximate anti-aliasing (FXAA), 2009.

[POM17] PEREZ-ORTIZ M., MANTIUK R. K.: A practical guide and software for analysing pairwise comparison experiments. arXiv preprint (dec 2017). URL: http://arxiv.org/abs/1712. 03686,arXiv:1712.03686.

[SWD05] SHARMA G., WU W., DALAL E. N.: The CIE DE 2000 color difference formula: Implementation notes, supplementary test data, and mathematical observations. 21–30.