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Exploiting the limitations of spatio-temporal vision for more efficient VR rendering

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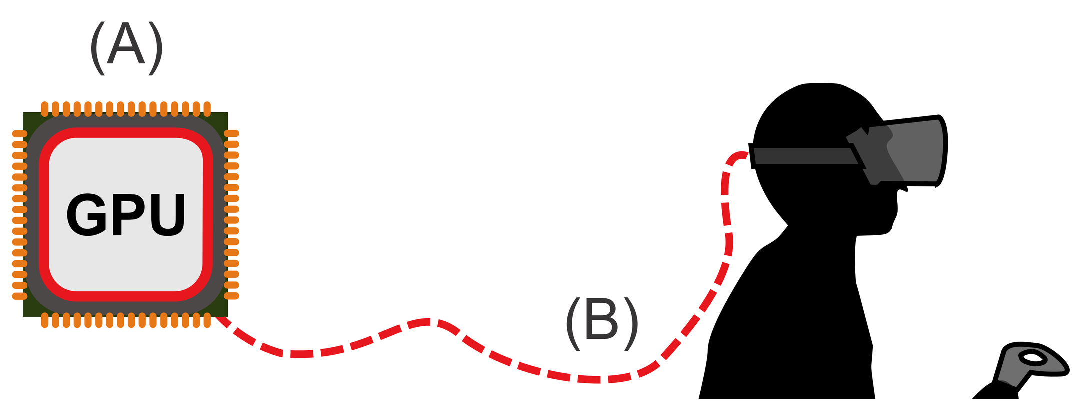
GENERATIONS SIGGRAPH2018

Problem

Reduce the cost of (A) *rendering* and (B) *transmission* for virtual reality (**VR**) without perceivable loss of quality.



Motivation

Rendering in VR is exclusively expensive due to the requirements on display resolution, anti-aliasing and refresh rate ($90Hz$) .

However, the angular resolution of headsets is 10x lower than that of a desktop monitor.

Additionally, transmission of frames to the headset requires high-bandwidth dedicated links, especially in a wireless setup.

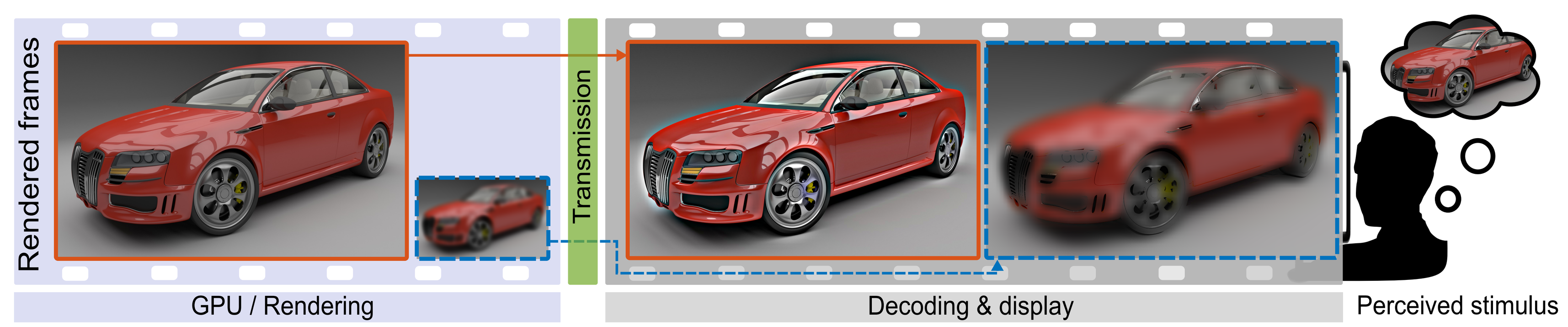
Current temporal approaches [Beeler et al. 2016, Vlachos 2016] exploit spatial coherence between consecutive frames by rendering only every *k*-th frame; in-between frames can be generated by transforming the previous frame. These techniques, however, are only recommended as a last resort [Vlachos 2016].

Our Approach

A temporal multiplexing algorith that takes advantage of the limitations of the visual system:

1. finite integration time results in fusion of rapid temporal changes
2. the inability to perceive high-spatial-frequency signals at high temporal frequencies.

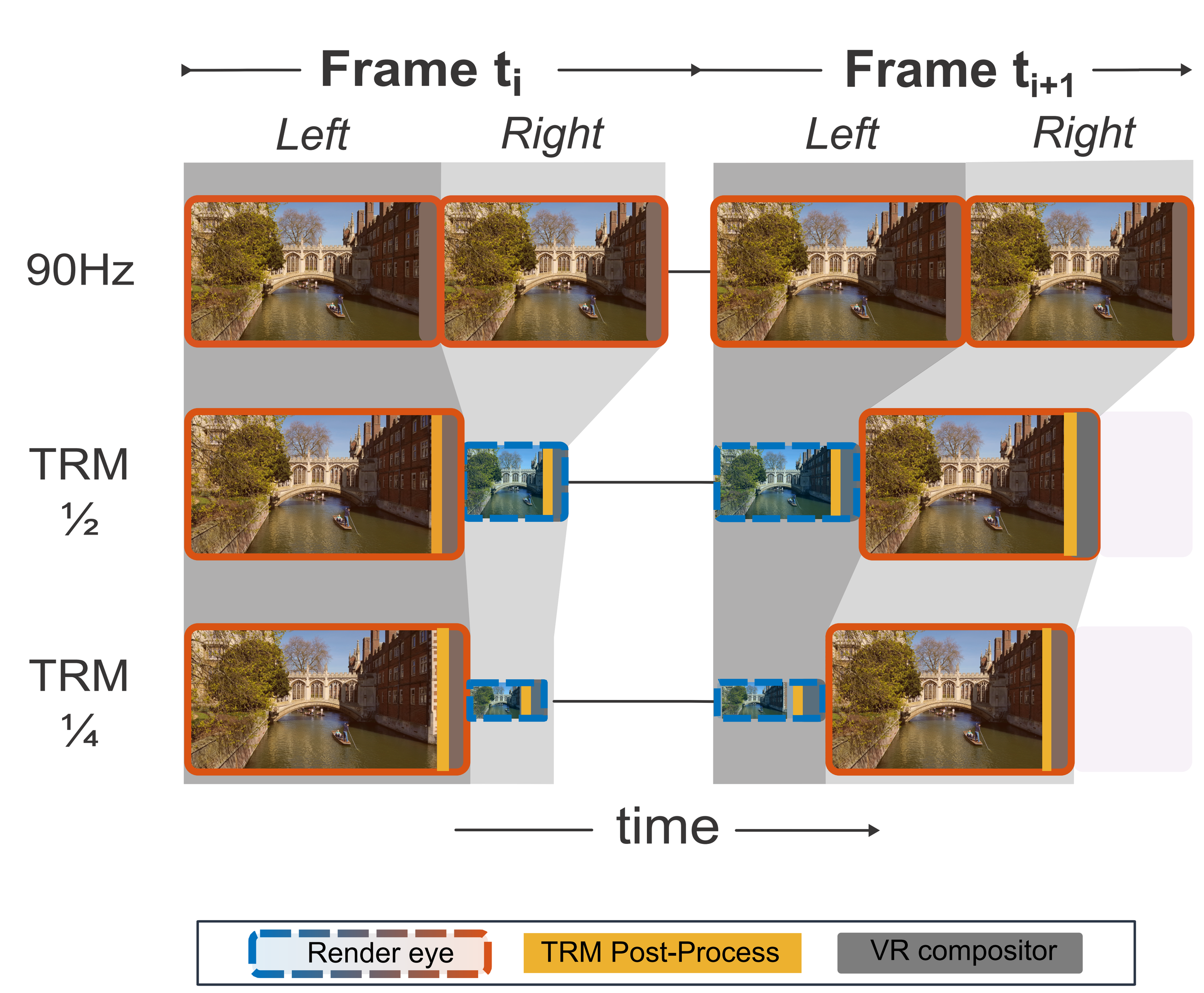
Method



Our proposed method, Temporal Resolution Multiplexing (**TRM**), renders **even-numbered frames** with **reduced resolution**. Before displaying:

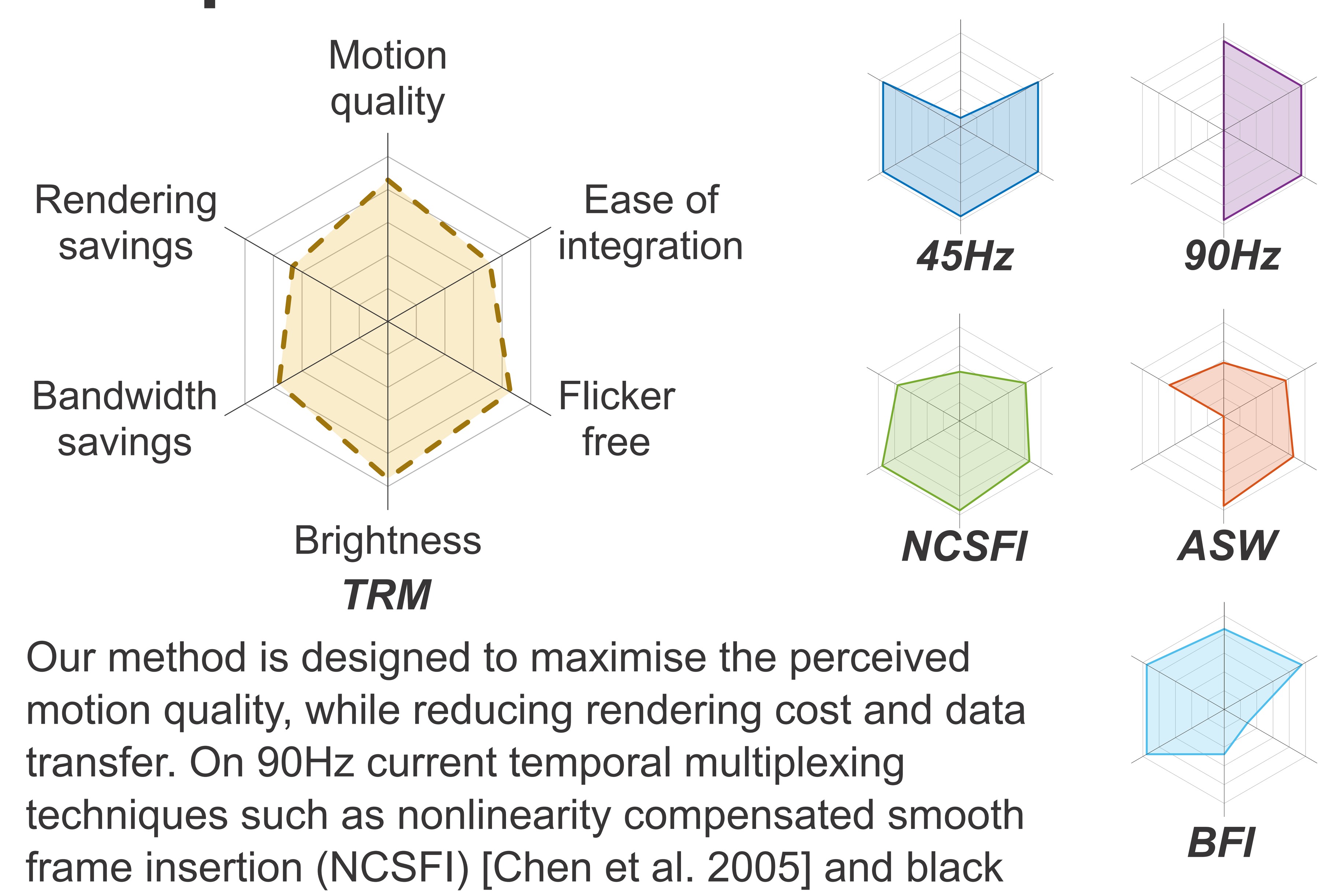
1. **Odd-numbered frames** are compensated for the loss of high frequencies.
2. Values that are lost while clamping to the dynamic range of the display are stored in a temporary residual buffer
3. The residual is added to the next **even-numbered frame** with a weight mask that takes motion into account.

When the sequence is viewed at high frame rates (> $90Hz$), the visual system perceives the original, full resolution video.



In the binocular setup we alternate the reduced-resolution and compensated frames off-phase for the two eyes. With a naive OpenGL/OpenVR implementation we acheived a steady 19-25% speed-up with this setup

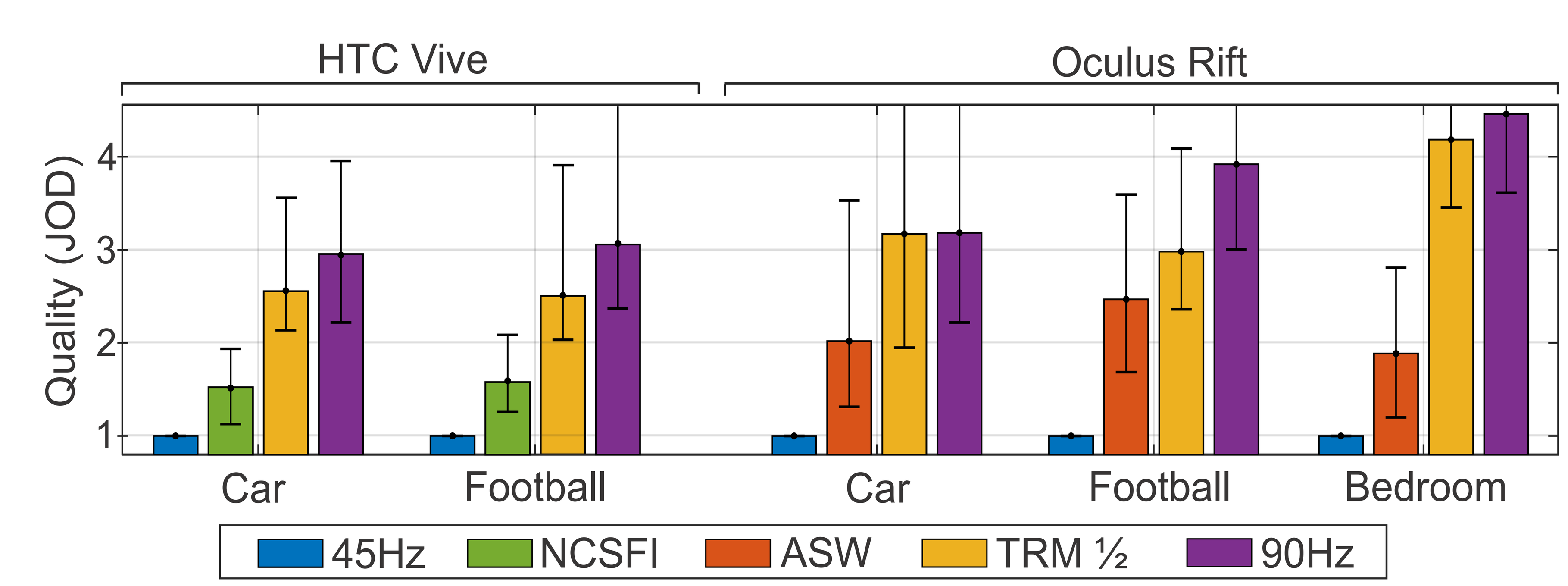
Comparison



Our method is designed to maximise the perceived motion quality, while reducing rendering cost and data transfer. On 90Hz current temporal multiplexing techniques such as nonlinearity compensated smooth frame insertion (NCSFI) [Chen et al. 2005] and black frame insertion (BFI) either result in motion artifacts or flicker.

Results

In a subjective user experiment we compared the perceived quality of TRM to 90Hz, 45Hz (no reprojection), state-of-the-art NCSFI and ASW. TRM performed consistently better both on the HTC Vive and the Oculus Rift.



References

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Dean Beeler, Ed Hutchins and Paul Pedriana. 2016 Asynchronous Spacewarp. https://developer.oculus.com/asynchronous-spacewarp/. (2016) Accessed: 2018-06-14
Hanfeng Chen, Sung-soo Kim, Sung-hee Lee, Oh-jae Kwon and Jun-ho Sung. 2005. Nonlinearity compensated smooth frame insertion for motion-blur reduction in LCD. In *2005 IEEE 7th Workshop on Multimedia Signal Processing*. IEEE, 1-4. https://doi.org/10.1109/MMSP.2005.248646