Latency-Driven Optimization for Foveation in Remote Rendered VR

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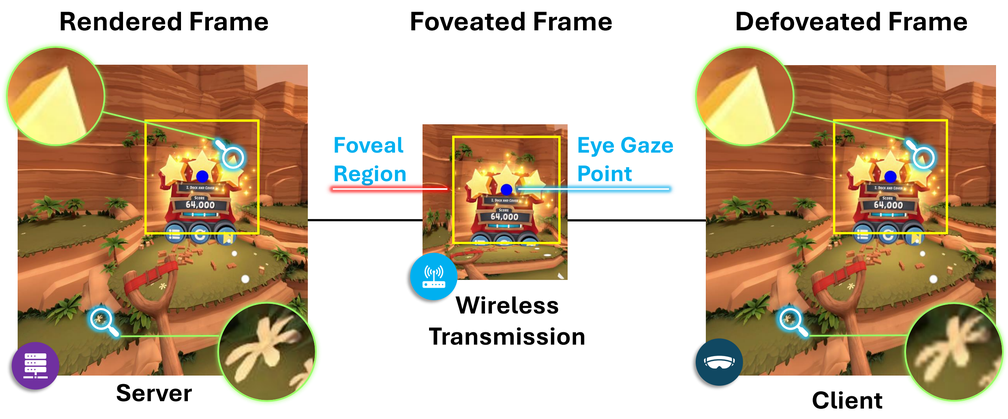
ACM
Multimedia 2026
Rio de Janeiro, Brazil

Gaze Prediction · Stabilization · Adaptive Foveation

Built on D-AADT2 gaze-adaptive foveation · ACM MM ’25

Motivation

Introducing end-to-end foveation mechanisms



- **Server Processing:** Compresses the periphery while retaining **high foveal detail**, downscaling and encoding the frame for transmission.
- **Client Restoration:** Decodes the received frame and defoveates it back to its full-resolution state.

Latency causes gaze-fovea misalignment

ACM MM’25

gaze
↓
D-AADT2 follows gaze
↓
dynamic foveation

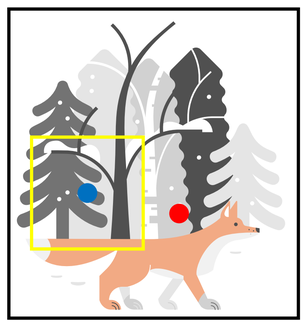
ACM MM’26

gaze + latency
↓
LDO anticipates gaze
↓
latency-aware foveation

[MM’25]
Where is the user looking?

[MM’26]
Where will the user be looking when the frame is displayed?

Display time



Delayed foveal region caused by latency

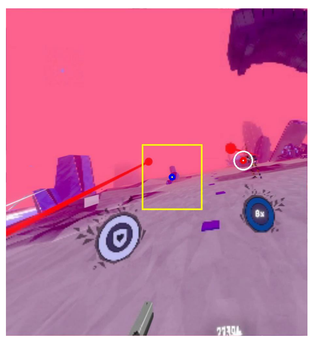
User’s actual gaze

LDO Framework

Treat latency as a control policy

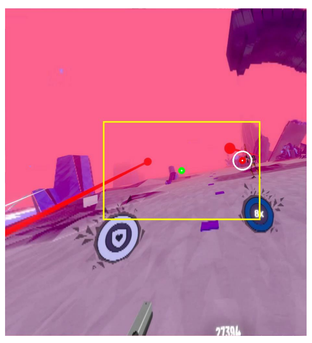
delayed gaze
↓
Gaze Prediction predicted gaze
Hysteresis stable center
Adaptive Foveal Size adaptive region
↓
D-AADT2 shader
↓
H.265 Stream
↓
VR Headset

D-AADT2



delayed gaze
current gaze
fixed D-AADT2 foveal region (high image fidelity)

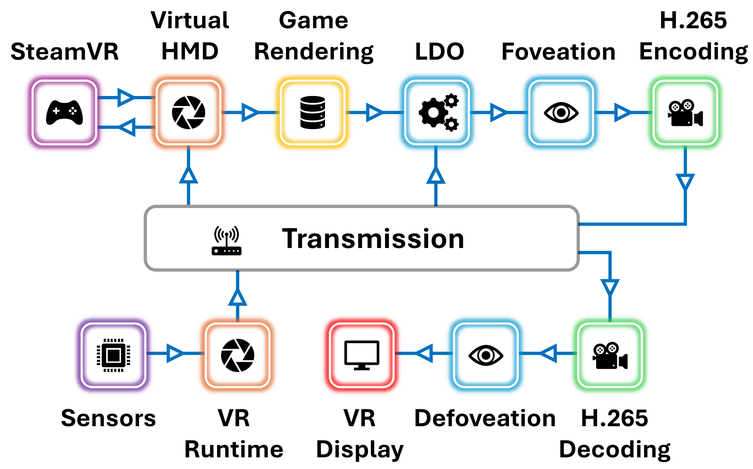
LDO



predicted gaze
current gaze safely inside
adaptive foveal region (high image fidelity)

- **Predict where to place quality and enlarge it only when necessary.**

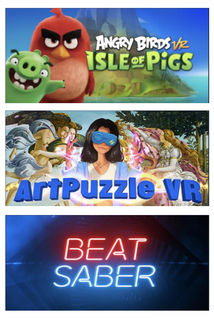
Remote Rendering Pipeline



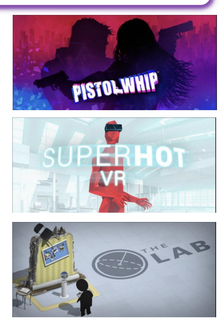
- **Our remote rendering pipeline is built on Air Light VR (ALVR).**

Objective Evaluation

D-AADT2 **LDO**



≈33.3 dB
±36 dB
±30 dB
±33.5 dB
±35.2 dB
±35.3 dB



±35 dB
±37 dB
±32 dB
±32.7 dB
±36 dB
±36.8 dB

Baseline MTP
60.9 – 79.4 ms

Mean error reduction

+30 ms	+60 ms	+90 ms
17.8%	24.2%	28.4%

+1–4 dB EWPSNR

+0.2–0.8 FovVideoVDP

- **LDO becomes more valuable as latency increases.**

User Study Evaluation

LDO **EyeNexus**



Overall Quality: *p=.026*

Visual Quality: *p=.0030*
86.7% vs 56.7%

- **LDO significantly improves perceived visual quality and overall quality over the current state-of-the-art.**
- **LDO has a perceptually favourable user experience across all evaluated metrics.**

Better alignment · Fewer Misses · Higher Perceptual Quality

References:

- Widagdo, Adhi, et al. "Gaze-Adaptive Foveation for Remote Rendered VR." *Proceedings of the 33rd ACM International Conference on Multimedia*. 2025.
- Wu, Ze, et al. "Eyenexus: Adaptive gaze-driven quality and bitrate streaming for seamless vr cloud gaming experiences." Proceedings of the ACM on Networking 3.CoNEXT4 (2025): 1-25.

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Try Dyna-ALVR with SteamVR games.
Explore gaze-adaptive foveation and latency-driven optimization from our ACM Multimedia research.

github.com/adhi-w/Dyna-ALVR