Guiding Viewer Attention to Highlights in VR 360-degree Panoramas via View Direction Control

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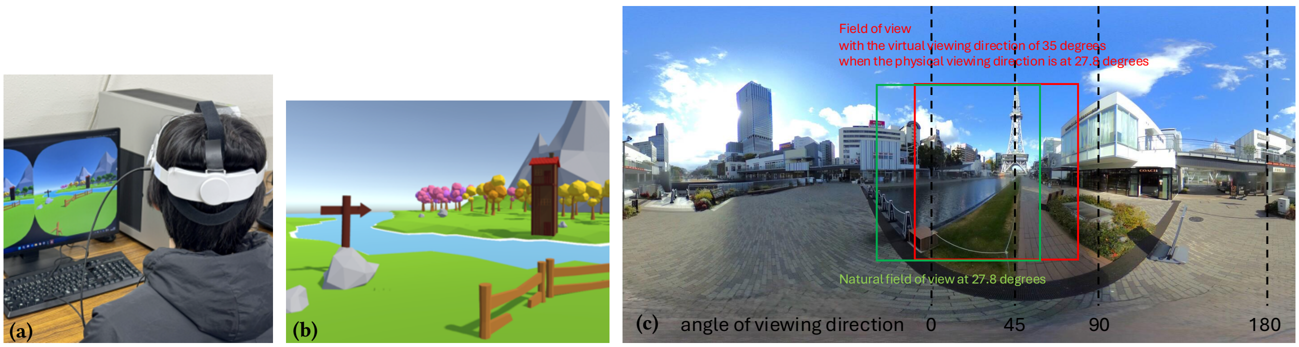

Figure 1: Our method guides users toward highlights by modulating view-direction gain, resulting in more stable and focused observation compared to conventional viewing: (a) Evaluation setup. A participant wearing an HMD during the study, (b) Example view from a participant's perspective in the CG environment used for evaluation, and (c) Real-world 360° panoramic image used for evaluation, captured in an urban environment (Sakae, Nagoya, Japan).

Abstract

In head-mounted display (HMD) viewing of 360° panoramic images, viewers freely explore the scene, making it difficult for creators to ensure that designated highlights are reliably attended to. We propose a view-direction control method based on a piecewise linear mapping between physical and virtual viewing directions. We amplify rotational gain when users move toward highlights and attenuate it near them, encouraging stable observation. The control function is smoothed using cubic Bézier curves. Our evaluations show that the proposed method improves the visibility of highlights, and a follow-up study with real panoramic images further demonstrates its effectiveness.

CCS Concepts

• **Human-centered computing** → **Interaction design**; *Virtual reality*.

Keywords

Virtual Reality (VR), 360° Panoramas, Attention Guidance, Rotational Gain, View Direction Control

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1 Introduction

Consumer head-mounted displays (HMDs) have enabled widespread use of 360° panoramic images for virtual tourism, museum exhibitions, and cultural heritage applications. However, users may overlook important content when freely exploring such environments. In these settings, users freely control their viewing direction [1], making it difficult for creators to ensure that intended points of interest—highlights—are reliably attended to. Prior work has explored modifying the mapping between physical and virtual viewing directions. Bolte et al. [2] amplified head rotation to support efficient exploration, while Inagaki and Funahashi [3, 4] improved rearward visibility. However, these approaches are not designed to guide attention toward specific highlights. We propose a view-direction control method that modulates rotational gain based on the location of highlights, encouraging users to attend to them while maintaining stable viewing behavior. Our contributions are (1) a view-direction control method for guiding attention to highlights, and (2) an evaluation demonstrating its effectiveness in both controlled and real-world settings.

2 Proposed method

In conventional HMD viewing, the virtual viewing direction matches the physical viewing direction. Our method modifies this mapping (Fig. 2(a)) to facilitate gaze shifts toward highlights while suppressing movement near them. Let p denote the horizontal angle of the

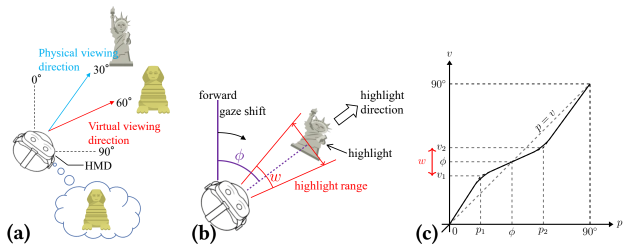


Figure 2: Overview of the proposed method: (a) mapping between physical and virtual viewing directions, (b) definition of the highlight direction ϕ and its angular range w, and (c) the view-direction control function.

physical viewing direction ($-90 \leq p \leq 90$), and v the corresponding virtual viewing direction. Let ϕ denote the highlight direction and w the angular width of the highlight region (Fig. 2(b)). Within a region centered at the highlight ($|v - \phi| \leq w/2$), p and v are related by a linear function with slope s ($0 < s < 1$), reducing sensitivity near the highlight. Outside this region, the slope exceeds 1, thereby accelerating movement toward the highlight, as defined in Equation (1):

$$v = s(p - \phi) + \phi \quad (p_1 \leq p \leq p_2) \tag{1}$$

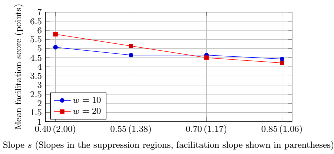
where $p_1 = \phi - w/2s$ and $p_2 = \phi + w/2s$ (Fig. 2(c)). Slope discontinuities at the breakpoints are smoothed using cubic Bézier curves with half-length L. This design encourages users to approach highlights more quickly while stabilizing gaze near the highlights.

3 Evaluation

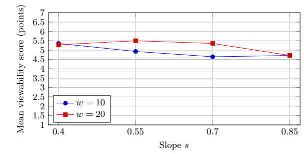
We evaluated the proposed method through two studies: a controlled parameter study in a CG environment and a validation study using a real 360° panoramic image.

Study 1: Parameter Evaluation. Fourteen participants evaluated eight parameter settings defined by $w = 10°, 20°$, $s = 0.40, 0.55, 0.70, 0.85$, and $L = 5$, using a Meta Quest 2 in a 3D CG environment (Fig. 1(a), (b)). Participants performed gaze-shift-and-return tasks toward targets located at ±40°, ±55°, and ±70°, followed by subjective ratings. Each condition was rated on 7-point scales relative to a no-control baseline: perceived speed (Q1), alignment ease (Q2), gaze stability (Q3), and discomfort (Q4). Results (Fig. 3) show that lower values of s improved perceived speed (Q1), while moderate settings ($w = 20°, s = 0.55$) achieved the best balance between alignment (Q2) and stability. However, overly small s increased discomfort (Q4).

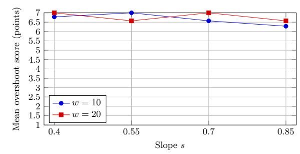
Study 2: Real-World Validation. We further evaluated the method using a real 360° panoramic image captured in an urban environment (Fig. 1(c)), where a tower structure was designated as the highlight. Based on Study 1, parameters were set to $w = 20°$ and $s = 0.55$, with the highlight direction fixed at 45°. Four participants viewed the scene under two conditions: with and without view-direction control. Each condition lasted 30 seconds, during which participants freely explored the scene. The proposed method improved highlight viewability (mean 4.25/5) and was reported



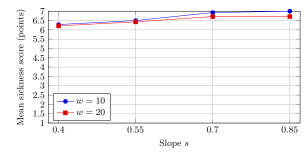
(a) Q1: Gaze-shift speed



(b) Q2: Alignment ease



(c) Q3: Gaze stability



(d) Q4: Perceived sickness

Figure 3: Results of Study 1: Lower values of s improve attention guidance speed, while moderate parameter settings achieve a balance between alignment ease and gaze stability, with a limited increase in perceived sickness: (a) gaze-shift speed (Q1), (b) alignment ease (Q2), (c) gaze stability (Q3), and (d) perceived sickness (Q4).

to naturally guide attention toward the highlight. Some participants experienced mild discomfort (mean 3.0/5), particularly when viewing regions away from the highlight.

4 Conclusion

We presented a view-direction control method for VR 360° panorama viewing that guides user attention to highlights by modulating the mapping between physical and virtual viewing directions. By increasing rotational gain toward highlights and reducing it near them, the method enables efficient and stable observation of important content. Our evaluation demonstrates that appropriate parameter settings improve highlight visibility while maintaining a balance between attention guidance, stability, and perceived discomfort. These results suggest that view-direction control is an effective approach for supporting attention guidance in immersive panoramic environments. Future work includes extending the method to support multiple highlights, further mitigating discomfort, and conducting larger-scale evaluations across diverse content and users.

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