Subtle Gaze Direction with Asymmetric Field-of-View Modulation in Headworn Virtual Reality

Dhrubo Jyoti Paul *
University of Florida

Eric D. Ragan †
University of Florida

ABSTRACT

Virtual reality allows users freedom to interactively look around, but designers sometimes want to encourage attention to certain areas of interest without directly interrupting the user. Our research presents asymmetric changes to field of view in head-worn virtual reality as a means of subtle encouragement of user gaze direction. Preliminary study results indicate this method can induce turning behavior, but viewer reactions may not be consistent. Asymmetric reduction in the visual field can create curiosity and induces movement towards or away from the reduced direction. Preliminary results indicate participants more often looked towards the reduced direction to compensate for what they were missing. Further, some participants were not able to detect field of view modulations.

Index Terms: Virtual Reality—Redirection—Field of View Manipulation; Virtual Reality—Redirection—Subtle Gaze Redirection;

1 INTRODUCTION

In immersive environments where the viewer is free to look at any direction, gaze direction techniques can be a useful instrument for times when designers or developers want to encourage users to view areas of interest without directly taking control from the user. Virtual content such as 360 degree video, games can sometimes be confusing for the viewers as every direction is open for consumption. Complete viewing freedom when there is an intended viewing target can lead to decision fatigue and make being in the environment a strenuous visual search task. Gaze direction methods in such contexts can help content creators encourage the viewer to look at a desired scene in an immersive movie, or augment view redirection methods and enhance comfort [3].

Since immersive feelings and free interactive viewing are largely considered to be major benefits of reality, redirection techniques preferably would not disrupt the the experience. Ideally, any direction would be unnoticeable enough that the user does not feel forced or constrained [2–4]. To achieve such experiences, subtle techniques are often desired when encouraging attention to different visuals [1].

In this study, we explore a novel method for directing gaze through asymmetric manipulation of the viewer's field of view (FoV) via a virtual mask. The rationale behind this technique is that asymmetrically altering the FoV may encourage the viewers to change their position in order by either (a) turn towards the direction with lost view coverage to compensate for reduced visuals, or (b) turn away from the mask to restore a larger FoV.

2 ASYMMETRIC MODULATION TECHNIQUE

To achieve an asymmetric FoV, our implementation of the modulation technique renders two black masks directly in front of the camera. The shape of the masks resembles the FoV shape of the existing borders of the headworn display. Modulation and asymmetry can be controlled dynamically. When activated, the FoV is asymmetrically reduced by shifting one of the two masks from the left or right side of the camera. The mask can be gradually demodulated to the original state after either a fixed duration or in response to viewing behavior based on head tracking data.

When such a modulation is instantiated, the effective FoV shifts to one side. This asymmetry may encourage the user to look away from the black mask or look towards the black mask.

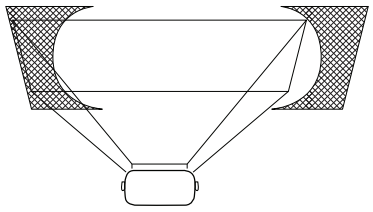

Figure 1: Overview of the technique while a modulation instance is ongoing. Note that the black mask coming from the left is reducing the angle of view and creating an asymmetric viewing area.

3 PRELIMINARY EVALUATION

We implemented a proof-of-concept version of the technique, and we conducted a preliminary user study to test its effects. The study had two goals. First, we sought to study if and how participants changed their viewing in reaction to the asymmetric FoV modulation. Secondly, we investigated whether users would detect the FoV change.

The study tested two configurations of the technique with varying levels of mask duration, transition speeds, and magnitude of FoV masking. Table 1 provides an overview of the two configurations, which we refer to as *strong* and *weak* modulation. We tested the techniques in a within-subjects study with eight participants (all graduate students in computing and engineering disciplines).

The primary aim of the study scenario was to distract the participants into thinking about the details of the environment without explicitly providing strong viewing goals so we could test the effects of FoV modulation without interference from task goals. To this end, the participants were exposed to a simple virtual environment (see Figure 2) for fourteen minutes. Participants were seated with head-tracking enabled but without positional travel. While the scenario

	Strong	Weak
Activation time	6s	8s
Modulation state time	5s	5s
Return time	10s	10s
Maximum FoV reduction	17 degrees	12 degrees

Table 1: Configuration in different conditions of the independent variable- Strength. The given FoV reduction has been calculated based on the (very approximate) advertised Field of View of 110 degrees for the Oculus Rift CV1

*e-mail: d.paul@ufl.edu
†e-mail: eragan@ufl.edu

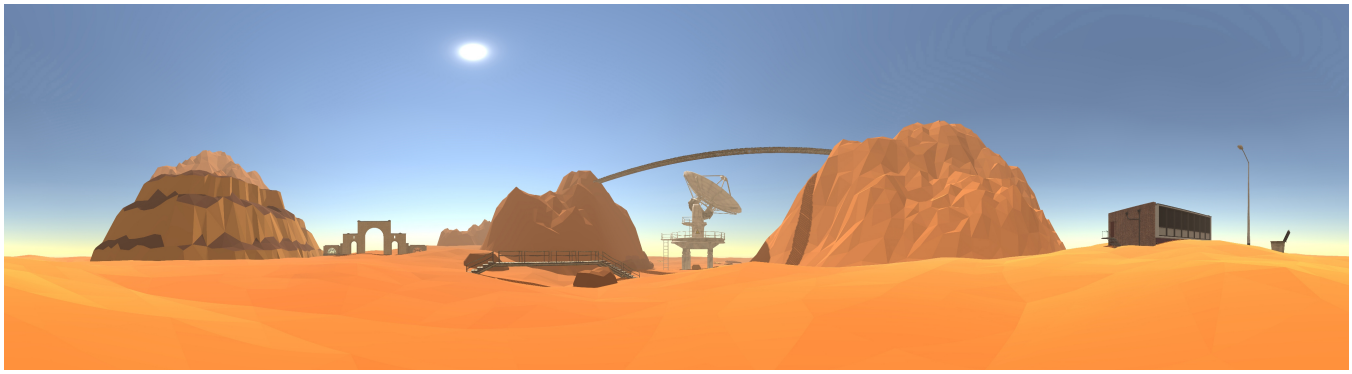

Figure 2: The custom virtual environment designed for the study. This image flattens the 360 degree view to show the entire environment. Objects are distributed in all directions to distribute salient features.

had no real goals and was not presented as a game, the application did shown textual notifications to help keep the participants engaged. There were four sets of prompts, each ending with an open-ended question meant to be thought provoking for the participant to think about. In periods between sets of prompts, the FoV modulations were activated and head gaze orientation data was collected. The modulations were executed independent of gaze direction or objects being looked at during the study, and modulation time was based on fixed periods (see Table 1) rather than affected by viewing.

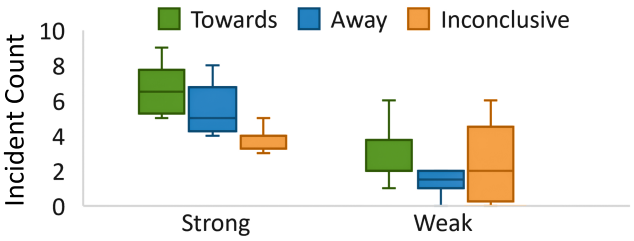

Figure 3: Participants' reactions to strong and weak FoV modulation.

3.1 Results and Discussion

Preliminary study results are based on physical head rotations following activation of the technique. When a modulation reached its fully-modulated state, the head position at that moment was recorded, and rotational deviation from that position was recorded thereafter for the rest of the modulation duration to understand the effects caused by the asymmetric FoV mask. As part of preliminary work, the collected movement data was manually reviewed by a member of the research team to understand the behavior caused by the modulation. For each instance of activated modulation, we coded the viewing behavior as either: (1) redirecting the gaze *towards* the masked side, (2) redirecting *away* from it, or (3) *inconclusive* if there was no clear direction or little turning.

Figure 3 summarizes the viewer reactions. As the technique is designed to be subtle and does not "force" turning, it is not surprising that many instances of modulation were followed by inconclusive viewing reactions. In some cases, participants rotated their view to neutralize the reduction in FoV and keep the object they were looking at centered. The viewer's interest to look at an object is understandable, and the the ability to retain support for free view control is an important aspect of the technique.

However, the preliminary study results do indicate greater reactions to modulation with the stronger version of the technique. Also, among the cases where participants had noticeable reactions to the modulation, the results show a clear pattern in that they tended to turn *towards* the mask more often then *away* from it.

Further, due to the within-subjects design, all participants experienced both *weak* and *strong* variations of the technique, which greatly increased the probability of participant detection of the technique due to the more intense *strong* variation. Nevertheless, three out of the eight participants did not report any changes in FoV when questioned about issues or view changes in a post-study interview. Prior VR studies have found numerous cases where users do not easily detect view manipulations (e.g., [2–4]), and we expect we would find notably less detection without inclusion of the strong variation, but further study would be needed to ascertain detection thresholds for asymmetric FoV changes.

4 Conclusion and Future Work

Our research presents asymmetric FoV modulations as a means of influencing gaze direction. Preliminary study results indicate this method can induce turning behavior, but viewer turning reactions may not be consistent. Based on our study, people often tend to look towards the masked side more to compensate for what they are missing. Analyzing the different stages of such modulation can further clarify the behaviors and help leverage this influence in practical scenarios.

Since the obtained result is based on the one environment designed for the study, testing with alternative environments is needed for more generalized results. Also, while modulation in this study was activated without consideration or feedback from users' viewing behavior, the next steps of this research include positively reinforcing turning behaviors to subconsciously train them the desired redirection behavior. For example, if the user tends to look towards the mask, then from then on, looking towards the mask could be used as an input to reduce the mask to reward similar responses in the future.

References

[1] R. Bailey, A. McNamara, N. Sudarsanam, and C. Grimm. Subtle gaze direction. *ACM Transactions on Graphics (TOG)*, 28(4):100, 2009.

[2] A. S. Fernandes and S. K. Feiner. Combating VR sickness through subtle dynamic field-of-view modification. In *2016 IEEE Symposium on 3D User Interfaces (3DUI)*, pp. 201–210. IEEE, 2016.

[3] T. Stebbins and E. D. Ragan. Redirecting view rotation in immersive movies with washout filters. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pp. 377–385. IEEE, 2019.

[4] F. Steinicke, G. Bruder, J. Jerald, H. Frenz, and M. Lappe. Estimation of detection thresholds for redirected walking techniques. *IEEE transactions on visualization and computer graphics*, 16(1):17–27, 2009.