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An Evaluation of Dichoptic Tonemapping in Virtual Reality Experiences



Fachgruppe Virtual & Augmented Reality

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Overview



To study the influence of dichoptic tonemapping on depth perception, participants complete a block matching game in two environments (Street, Cafe). Left: One participant group is presented with dichoptically tonemapped image-pairs. These images exhibit different contrast curves for each eye (labeled as L and R). The goal of the game is to position a moveable block directly above a random opening in the underlying plane. Right: The game is divided into three difficulty levels, where each level increases the block's distance from the target surface.

Introduction

Dichoptic Tonemapping aims at increasing the overall contrast and detail level of a scene, by presenting two differently tonemapped images to the viewer. While each image is shown exclusively to one eye, the combined binocular percept is theorized to contain the luminance ranges of both images. In addition to this quality, recent research has shown that dichoptic tonemapping can also lead to an increased sensation of subjective depth [3][4]. Important aspects of this technique, such as its impact on presence or cybersickness, have not yet been thoroughly explored in the context of Virtual Reality (VR). In our work, we address this gap via a user study, where a dichoptic and non-dichoptic group are compared. In addition, we examine if the subjective sensation of depth also extends to an improved performance in depth-based tasks.

Results Δ VRSQ Task Error (Street) Task Error (Cafe) 1.2 Dichoptic 30 Non-Dichopti 1.0 1.020 0.8 0.8 0.6 0.6 10 0.4 0.4 0.2 0.2 -100.0 Difficulty 2 Difficulty 3 Difficulty 2 Difficulty 3 0 D

Presence: Performing a Mann-Whitney-U-Test on the IPQ results did not show any significant influence of dichoptic tonemapping on Spatial Presence (U = 981.5, p = .797), Realism (U = 490.5, p = .0711) or General Presence (U = 35.0, p = .6418). A significant difference was found for

Experiment

- Eighteen individuals (9M, 9F) were recruited for the experiment, and were equally divided into a dichoptic (DTM) and a non-dichoptic (TM) test group. All rendered images were tonemapped using the ACES^a technique. The images for the DTM group have been additionally processed with the dichoptic tonemapper by Zhong et al. (DiCE) [4].
- Participants complete multiple iterations of a block matching game (teaser) figure), where a moveable block must be aligned directly above a randomly positioned opening in a dense 11x11 grid of blocks. Three difficulty levels are implemented, with each level increasing the vertical distance between the moveable block and the underlying grid. The task performance of each participant is measured by computing the Euclidean distance between the placed block's position and the center of the opening.
- ▶ The study takes place in the Amazon Lumberyard Bistro scene. To account for different luminance distributions which could affect the dichoptic tonemapping result, the scene is divided into an interior (Cafe) and exterior (Street) part.
- At the start of the experiment, participants fill out a pre-immersion VRSQ[1] questionnaire, and are placed into an introductory environment. Here, an explanation of the matching task and a short training session are performed.
- The experiment starts with one of two randomly chosen environments (Cafe or Street). Each participant performs 45 repetitions of the block matching game, with 15 repetitions for each of the three difficulty levels. The same procedure is repeated for the second environment. The experiment is concluded with an IPQ

- Involvement (U = 426.0, p = .0105), which was rated lower for DTM.
- **Task Performance**: A significant difference was found between both conditions for the second difficulty level performed in the street environment (U = 7377.0, p = .009), where DTM (M = 0.241, SD = 0.195)achieved a lower task error than TM (M = 0.284, SD = 0.198).
- Cybersickness: The difference between the post- and pre-immersion VRSQ sub-scores is computed (Δ VRSQ). A one-sample t-test confirmed that all three Δ -scores of DTM significantly deviate from zero - (Oculomotor: t(8) = 2.45, p = .04), (Disorientation: t(8) = 3.465, p = .008), (Total: t(8) = 3.127, p = .014). This was not the case for TM.

Conclusion

Dichoptic tonemapping may improve task performance, however, it is not clear if this improvement is attributable to an increased depth sensation, or if it is the result of a more appropriate contrast ratio of the component images. Our results show that the use of dichoptic tonemapping can lead to an increase in cybersickness related symptoms. To precisely quantify the amount, a larger sample size is required. The conducted experiment did not reveal any benefits of dichoptic tonemapping on user presence.

References

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