frontiers | Frontiers in Virtual Reality

TYPE Editorial
PUBLISHED 07 October 2022
DOI 10.3389/frvir.2022.1025054

OPEN ACCESS

EDITED AND REVIEWED BY
Ronan Boulic,
Swiss Federal Institute of Technology Lausanne, Switzerland

*CORRESPONDENCE
Diego Monteiro,
Diego.VilelaMonteiro@esiea.fr
Hai-Ning Liang,
HaiNing.Liang@xjtlu.edu.cn

SPECIALTY SECTION
This article was submitted to Virtual Reality in Medicine, a section of the journal Frontiers in Virtual Reality

RECEIVED 22 August 2022
ACCEPTED 06 September 2022
PUBLISHED 07 October 2022

CITATION
Monteiro D, Nanjappan V, Baghaei N and Liang H-N (2022), Editorial: Cybersickness in VR applications. *Front. Virtual Real.* 3:1025054. doi: 10.3389/frvir.2022.1025054

Editorial: Cybersickness in VR applications

Diego Monteiro[1]*, Vijayakumar Nanjappan[2], Nilufar Baghaei[3] and Hai-Ning Liang[4]*

[1]Digital Engineering School, ESIEA, Laval, France, [2]Center for Ubiquitous Computing, University of Oulu, Oulu, Finland, [3]School of Information Technology and Electrical Engineering, The University of Queensland, Brisbane, QLD, Australia, [4]X-CHI Lab, Department of Computing, Xi'an Jiaotong-Liverpool University, Suzhou, Jiangsu, China

KEYWORDS

cybersickness, virtual reality, mitigation, mechanism and characterization, application

Editorial on the Research Topic
Cybersickness in VR applications

1 Introduction

Virtual Reality (VR) Head-Mounted Displays (HMDs) have brought forth innumerable opportunities for research and applications. Examples include applications in medicine Li et al. (2017), education Checa and Bustillo (2020), and entertainment. Nevertheless, a frequent challenge for those who wear HMDs is the level of discomfort, VR Sickness, or cybersickness they experience Porcino et al. (2021); Kim et al. (2018). Regardless of naming conventions, important research specifically for HMDs has been done in the last decade to identify the causes of and solutions to cybersickness Porcino et al. (2021); Keshavarz et al. (2022); Stauffert et al. (2020); Monteiro et al. (2020). Despite recent advances in our understanding, there is still much that is unknown on the topic, especially regarding how cybersickness affects and is affected by each application of VR. This topic collection has collected five thought-provoking articles that help shed some further light on the issue of cybersickness. We divided this editorial into two parts based on papers reporting 1) mechanisms of cybersickness and 2) its mitigation in applications.

2 Mechanisms involved in cybersickness

Understanding the mechanisms behind cybersickness is vital to be able to identify solutions to mitigate or eliminate it. Some apparent smaller changes, like how the sense of self-motion is triggered, can influence the level of cybersickness. In this topic Teixeira et al. analyzed the influence of vection on cybersickness in a VR Game. This work stands out from similar works as it analyzes vection as an important component rather than assuming its existence and measuring other parameters. Moreover, there are some

recent works that have explored cybersickness in a VR gaming context (e.g., Monteiro et al. (2018, 2020); Chen et al. (2022); Wang et al. (2022b)) but not as many as in other contexts, making the paper by Teixeira et al.'s paper an important contribution to the topic of cybersickness in different VR environments. As the level of difficulty and challenge is a topic inherently linked to games, it is important to note that the difficulty of a task can affect the level of discomfort in VR.

Sepich et al. investigated how task workload influenced cybersickness in a VR Environment and observed that task workload could be linked to increased levels of cybersickness in a nonlinear fashion. Their results have shown that cybersickness would differ depending on the level of control and difficulty felt by users, which might narrow the validity of previous research. That is, their results bring attention to a challenge for cybersickness researchers: generalization. Studies that vary slightly in their methodology might result in entirely different outcomes. This challenge highlights the need for a standardized VR testing environment Lawson and Stanney (2021) or the use of predictive models for comparison within variations in the same environment (Islam et al. (2021); Monteiro et al. (2021); Wang et al. (2022a)).

3 Cybersickness mitigation

Reading is a common occurrence in asynchronous communication and recently, reading using a VR HMD has become more frequent. This increase in frequency includes reading while in moving vehicles, even though such action is a known contributor to discomfort. Tsukasa et al. explored how different backgrounds affected cybersickness in a moving vehicle when using an HMD. They observed in their investigation that having a see-through display behind the margins of the content could have a positive influence on the level of discomfort. Even though a see-through display can be part of the solution to being able to read in VR while in movement, it is likely not the only one.

On the same topic and with a few common associates with Suwa et al.,Sato et al. have proposed anchoring the text to earth to reduce the disjunction between felt and observed movement. They created a simulation with a moving platform and observed that for those who had the book tethered to earth, the levels of discomfort were lower than for those who read the text bound to the HMD. Could this approach be a solution for consuming 2D VR content in movement? More research is still needed to answer this question.

Adhanom et al. focused on a more general approach to reducing cybersickness. They investigated if it would be possible to carry over the adaptation from one abstract virtual environment to another naturalistic one. In other words, they investigated if it was possible to train participants not to get cybersick. Their results were promising and stood out even more after we observed that other variations in inputs (Teixeira et al. and Sepich et al.), can have significant differences in cybersickness outcomes and that the adaptation from one naturalistic environment does not necessarily translate to another Palmisano and Constable (2022). Though more research is needed, it is encouraging to imagine that by identifying the ideal abstractions, some general training might be possible in the future.

In summary, these articles show us the importance of defining our baseline well when studying cybersickness because even changing parts of a task might be a confounding factor. For example, when testing a mitigation technique, one should not alter the level of difficulty of the task or change from a passive to an active controller role. Moreover, when testing techniques, the order is important as VR adaptation might transcend scenarios, and some techniques can be helpful in specific environments Shi et al. (2021).

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Checa, D., and Bustillo, A. (2020). A review of immersive virtual reality serious games to enhance learning and training. *Multimed. Tools Appl.* 79, 5501–5527. doi:10.1007/s11042-019-08348-9

Chen, H., Shi, R., Monteiro, D., Baghaei, N., and Liang, H.-N. (2022). "Vrcockpit: Mitigating simulator sickness in vr games using multiple egocentric 2d view frames," in *2022 IEEE conference on games (CoG'22)*. doi:10.48550/ARXIV.2205.07041

Islam, R., Desai, K., and Quarles, J. (2021). "Cybersickness prediction from integrated hmd's sensors: A multimodal deep fusion approach using eye-tracking and head-tracking data," in *2021 IEEE international symposium on mixed and augmented reality* (Bari, Italy: ISMAR), 31–40. doi:10.1109/ISMAR52148.2021.00017

Keshavarz, B., Peck, K., Rezaei, S., and Taati, B. (2022). Detecting and predicting visually induced motion sickness with physiological measures in combination with machine learning techniques. *Int. J. Psychophysiol.* 176, 14–26. doi:10.1016/j.ijpsycho.2022.03.006

Kim, H. K., Park, J., Choi, Y., and Choe, M. (2018). Virtual reality sickness questionnaire (vrsq): Motion sickness measurement index in a virtual reality environment. *Appl. Ergon.* 69, 66–73. doi:10.1016/j.apergo.2017.12.016

Lawson, B. D., and Stanney, K. M. (2021). Editorial: Cybersickness in virtual reality and augmented reality. *Front. Virtual Real.* 2. doi:10.3389/frvir.2021.759682

Li, L., Yu, F., Shi, D., Shi, J., Tian, Z., Yang, J., et al. (2017). Application of virtual reality technology in clinical medicine. *Am. J. Transl. Res.* 9, 3867–3880.

Monteiro, D., Liang, H.-N., Tang, X., and Irani, P. (2021). "Using trajectory compression rate to predict changes in cybersickness in virtual reality games," in *2021 IEEE international symposium on mixed and augmented reality* (Bari, Italy: ISMAR), 138–146. doi:10.1109/ISMAR52148.2021.00028

Monteiro, D., Liang, H.-N., Wang, J., Chen, H., and Baghaei, N. (2020). "An in-depth exploration of the effect of 2d/3d views and controller types on first person shooter games in virtual reality," in *2020 IEEE international symposium on mixed and augmented reality*, 713–724. doi:10.1109/ISMAR50242.2020.00102

Monteiro, D., Liang, H.-N., Xu, W., Brucker, M., Nanjappan, V., and Yue, Y. (2018). Evaluating enjoyment, presence, and emulator sickness in vr games based on first- and third- person viewing perspectives. *Comput. Animat. Virtual Worlds* 29, e1830. doi:10.1002/cav.1830

Palmisano, S., and Constable, R. (2022). Reductions in sickness with repeated exposure to hmd-based virtual reality appear to be game-specific. *Virtual Real.*, 1–17. doi:10.1007/s10055-022-00634-6

Porcino, T., Trevisan, D., and Clua, E. (2021). A cybersickness review: Causes, strategies, and classification methods. *J. Interact. Syst.* 12, 269–282. doi:10.5753/jis.2021.2058

Shi, R., Liang, H.-N., Wu, Y., Yu, D., and Xu, W. (2021). Virtual reality sickness mitigation methods: A comparative study in a racing game. *Proc. ACM Comput. Graph. Interact. Tech.* 4, 1–16. doi:10.1145/3451255

Stauffert, J.-P., Niebling, F., and Latoschik, M. E. (2020). Latency and cybersickness: Impact, causes, and measures. a review. *Front. Virtual Real.* 1. doi:10.3389/frvir.2020.582204

Wang, J., Liang, H.-N., Monteiro, D., Xu, W., and Xiao, J. (2022a). Real-time prediction of simulator sickness in virtual reality games. *IEEE Trans. Games* 1, 1. doi:10.1109/TG.2022.3178539

Wang, J., Shi, R., Xiao, Z., Qin, X., and Liang, H.-N. (2022b). Effect of render resolution on gameplay experience, performance, and simulator sickness in virtual reality games. *Proc. ACM Comput. Graph. Interact. Tech.* 5, 1–15. doi:10.1145/3522610