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Author(s)	Thanyadit, Santawat; Punpongsanon, Parinya; Piumsomboon, Thammathip et al.
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Substituting Teleportation Visualization for Collaborative Virtual Environments

Santawat Thanyadit
santawat@ust.hk
The Hong Kong University of Science and Technology
Clear Water Bay, Hong Kong

Parinya Punpongsanon
parinya@sys.es.osaka-u.ac.jp
Osaka University
Toyonaka, Osaka

Thammathip Piumsomboon
tham.piumsomboon@canterbury.ac.nz
University of Canterbury
Canterbury, New Zealand

Ting-Chuen Pong
tcpong@ust.hk
The Hong Kong University of Science and Technology
Clear Water Bay, Hong Kong

ABSTRACT

Virtual Reality (VR) offers a boundless space for users to create, express, and explore in the absence of the limitation of the physical world. Teleportation is a locomotion technique in a virtual environment that overcomes our spatial constraint and a common approach for travel in VR applications. However, in a multi-user virtual environment, teleportation causes spatial discontinuity of user's location in space. This may cause confusion and difficulty in tracking one's collaborator who keeps disappearing and reappearing around the environment. To reduce the impact of such issue, we have identified the requirements for designing the substituted visualization (SV) and present four SVs of the collaborator during the process of teleportation, which includes hover, jump, fade, and portal.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; **Visualization**.

KEYWORDS

Virtual Reality, Teleportation, Locomotion

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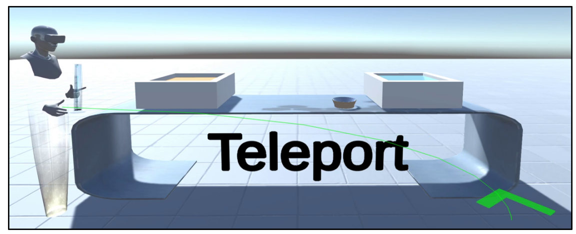

Figure 1: The common *line visual cues* for teleportation.

1 INTRODUCTION

Teleportation is a common locomotion technique in Virtual Reality (VR) that instantly transports a user from one location to another in a virtual environment (VE). This travel method solves the limitation of the finite physical space that we live in while we experience the infinite space offers in VE. To perform teleportation, the user typically aims for the target travel location in a straight line, as shown in Figure 1. While this is intuitive and efficient for applications with only a single user, in a multi-user virtual environment, it could be challenging for the collaborators to keep track of one another, be aware of their collaborator's action, and maintaining communication. Moreover, one might lose track of a collaborator completely when teleportation is performed in succession.

This issue leads to inefficiency or even errors during a collaborative session. For instance, a student might lose track of the instructor in a virtual classroom, which might cause an interruption to the learning process or missing a crucial instruction. *Getting There Together* [4] tackled this issue by proposing a pair teleportation techniques, which allowed the users to choose whether they want to teleport together with their collaborator. However, this only works when both users intend to teleport together while tracking another user's movement remains an issue. This issue could potentially pose a major problem in an asynchronous collaboration due to the absence of the collaborator's feedback [1].

We propose a number of visual representations during the teleportation, which we call substituted visualizations (SVs). SVs help the user to visualize their collaborator's movement during the teleportation process. Our research question is *"How various visualization techniques can help improve the user's awareness of their collaborator during teleportation?"*. This research investigated this research question by examining the requirements for designing SV and provided four examples of SV design suitable for different situations.

2 VISUALIZATION DESIGN

We considered four primary factors as our design requirements of SV, which are namely time efficiency, traceability, intuitiveness, and recognizability. We listed our design requirements with a brief

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Table 1: Design requirements of the substituted visualizations (SV)

Requirements	Descriptions
Time efficiency	The SV's duration should be independent of the teleportation distance. In a dependent case, long-distance teleportation would result in a long SV duration. This would delay the subsequent actions of the user after being teleported. However, this would not be an issue for asynchronous collaboration.
Traceability	SV should be traceable providing the information of the teleported user's origin and destination and the path taken to support teleportation in succession.
Intuitiveness	SV uses a familiar metaphor that the user can instinctively understand.
Recognizability	SV can be easily recognizable and interpret the user's intention to move prior to the execution, which would help improve the cognitive demand [2].

description in Table 1. We proposed four SV approaches based on these design requirements. In these approaches, the user's visual representation is presented as an avatar with a bust and hands based on the Oculus SDK, as shown in Figure 2.

Hover: The avatar moves in a straight line toward the destination at a constant speed while turning toward the target direction (Figure 2a). *Hover* simulates a walking motion, which makes it traceable, intuitive, and recognizable. However, the movement duration depends on the teleported distance and the movement speed, it is not time efficient. Moreover, the avatar could potentially collide with any obstacles in their path.

Jump: The avatar moves towards the destination using a parabolic trajectory similar to a jumping motion (Figure 2b). Hence, it is able to avoid obstacles. *Jump* is traceable and recognizable, but it is also distance-dependent and might not be as intuitive as *Hover*.

Fade: The avatar fades out from its original location and fades in at the destination (Figure 2c). *Fade* provides an additional time for the user to be aware of the teleportation. *Fade* is recognizable and time-efficient, but not traceable nor intuitive.

Portal: Inspired by a popular game "portal" [3], two portals fade in before the avatar move into the entrance of one portal and appear from the exit portal (Figure 2d). This technique is traceable, recognizable, and time-efficient, but not very intuitive.

3 CONCLUSION AND FUTURE WORK

From a pilot study with five participants, we found that *Hover* was the most preferable technique compared to the other SVs and the baseline condition without SV. Participants commented that *Hover* is the most intuitive condition. However, the tested scenarios were simple, which required only a single instance of teleportation. In the future, we will conduct further studies in more complex scenarios to better understand the limitations of the proposed SVs and come up with more novel SVs for various collaborative situations.

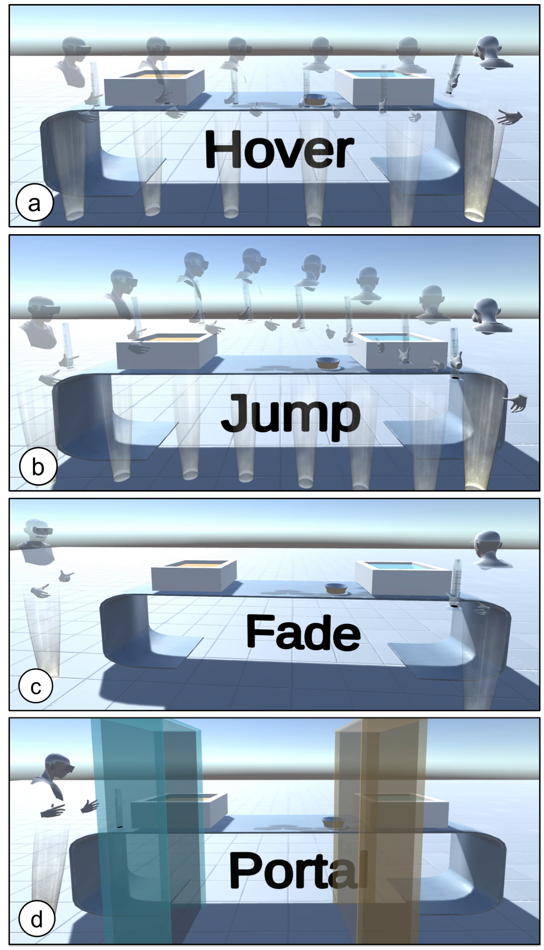

Figure 2: Proposed teleportation visualizations: (a) Hover SV, (b) Jump SV, (c) Fade SV, and (d) Portal SV.

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REFERENCES

[1] Kevin Chow, Caitlin Coyiuto, Cuong Nguyen, and Dongwook Yoon. 2019. Challenges and Design Considerations for Multimodal Asynchronous Collaboration in VR. *Proc. ACM Hum.-Comput. Interact.* 3, CSCW, Article 40 (Nov. 2019), 24 pages. https://doi.org/10.1145/3359142

[2] Santawat Thanyadit, Parinya Punpongsanon, and Ting-Chuen Pong. 2018. Efficient Information Sharing Techniques between Workers of Heterogeneous Tasks in 3D CVE. *Proc. ACM Hum.-Comput. Interact.* 2, CSCW, Article 172 (Nov. 2018), 19 pages. https://doi.org/10.1145/3274441

[3] Valve. 2011. Portal 2. https://www.thinkwithportals.com/index.php. Accessed: 2020-08-17.

[4] T. Weissker, P. Bimberg, and B. Froehlich. 2020. Getting There Together: Group Navigation in Distributed Virtual Environments. *IEEE Transactions on Visualization and Computer Graphics* 26, 5 (2020), 1860–1870.