HyperJumping in Virtual Vancouver: Combating Motion Sickness by Merging Teleporting and Continuous VR Locomotion in an Embodied Hands-Free VR Flying Paradigm

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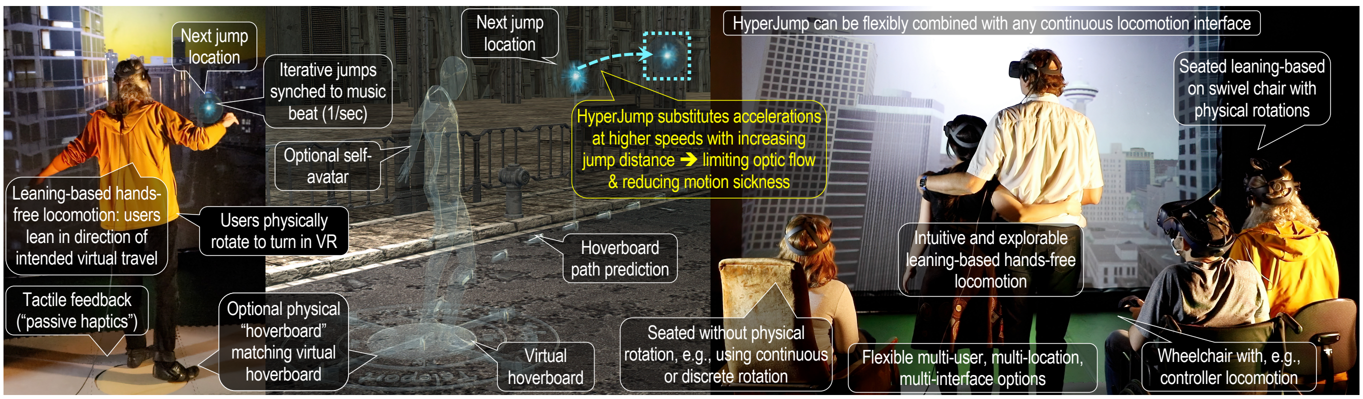

Fig. 1. Illustration of Hyperjump locomotion paradigm showing leaning-based (left) and other interface options (right)

Motion sickness, unintuitive navigation, and limited agency are critical issues in VR/XR impeding wide-spread adoption and enjoyable user experiences. To tackle these challenges, we present HyperJump, a novel VR interface merging advantages of continuous locomotion and teleportation/dashing into one seamless, hands-free, and easily learnable user interface supporting both flying and ground-based navigation across multiple scales.

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1 INTRODUCTION AND MOTIVATION

Virtual Reality (VR) is becoming increasingly powerful and affordable, yet as long as users experience motion sickness and cannot intuitively navigate, VR will never reach it's full potential, nor mainstream adoption. Indeed, up to 95% of VR users experience motion sickness effects like nausea, headache, dizziness, fatigue, or disorientation, and this has massive detrimental effects not only on their ability to use or really enjoy the experience, but also on the reputation and credibility of virtual and extended reality as a whole [Lawson 2014; Rebenitsch and Owen 2016; Saredakis et al. 2020]. This just might be the single most criticized aspect for it's mainstream adoption. Teleporting (manually selecting a target position or direction and instantaneously jumping to a new location) can help reduce motion sickness and travel time, but often negatively impacts presence, task performance, spatial orientation, and naturalism, especially if users need to repeatedly manually trigger jumps and/or select jumping locations [Bowman et al. 1997; Clifton and Palmisano 2020; Farmani and Teather 2020]. Other approaches to reduce motion sickness involve changing the visuals by, for example, reducing peripheral vision, adding stable reference frames, or blurring/occluding parts of the image [Chang et al. 2020; Farmani and Teather 2020; Fernandes and Feiner 2016; Zielasko et al. 2018]. While these can help reduce motion sickness at least to some degree, they also reduce the quality and naturalness of the visual simulation. Here, we present "HyperJump", a novel VR locomotion paradigm designed to merge advantages of both continuous and discontinuous locomotion [Farmani and Teather 2020] into one seamless interface that allows users to fly in VR without the need to manually switch locomotion modes or select individual teleport destinations. That is, as soon as the user would surpass velocity thresholds likely to induce sickness, HyperJump automatically adds iterative jumps (one per second) on top of the continuous movement.

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2 HYPERJUMP SYSTEM: MECHANICS, IMPLEMENTATION & PROTOTYPE

HyperJump allows for both flying and ground-based locomotion. It is designed for precise small-scale navigation as well as rapid longer-distance virtual travel. Despite enabling users to travel faster overall than traditional methods, informal pilot testing showed it could drastically reduce motion sickness even in susceptible users.

Mechanics. Users move their head and/or lean their upper body to move in the desired direction, in continuous motion; once a virtual speed is reached that would otherwise induce motion sickness, repeated jumps are introduced (one per second). Leaning further increases jump distance, but not frequency or continuous motion (optic flow) speed. I.e., users still perceive continuous embodied self-motion (vection) known to support presence, spatial orientation [Adhikari et al. 2022; Clifton and Palmisano 2020], and plausibility [Riecke and Schulte-Pelkum 2015] - albeit not at velocities/accelerations likely to induce motion sickness. To help users anticipate upcoming jumps, feel in control, and enhance maneuvering/path planning accuracy, we added a visualization of the future path (trail of arrows) and the future jump location (blue sprite, with a bubble expanding just before the next upcoming jump, see Fig. 1 and video explanation at youtu.be/IRZIytR4Wkw). In addition, when velocities approach this HyperJump speed threshold, the calm ambient music cross-fades to an up-beat soundtrack, and jumps sync with the 60bpm rhythm. User feedback indicated that these modifications help to increase predictability and maneuverability, and reduce "jarring" or "tripping" sensations previously observed when teleporting/dashing, especially when using an embodied (leaning-based) locomotion interface [Adhikari et al. 2022]. Informal user testing showed that adding HyperJumping drastically reduced motion sickness for all users.

Implementation. While HyperJump can be integrated with any continuous locomotion interfaces such as (hand-held) controller-based steering, here we demonstrate a hands-free and more embodied version, where users stand on a hoverboard and simply lean in the direction they'd like to travel (see Fig. 1). When physical user rotation is unfeasible (e.g., sitting on a couch or wheelchair), virtual rotation techniques (continuous, or discontinuous like rotation snapping) can be easily integrated [Farmani and Teather 2020]. As seen in the video explanation (youtu.be/IRZIytR4Wkw), users can maneuver very precisely across small- to large-scale environments (ground-based and flying), without having to switch interfaces or movement metaphor, or increasing risk of motion sickness.

3 PHYSICAL INSTALLATION AT IMMERSIVE PAVILION

The physical installation will feature HyperJump in a highly naturalistic Virtual Vancouver 3D model[1] such that users will have the unique ability to fly from the physical Vancouver Convention Center (SIGGRAPH 2022's location) out into the Virtual Vancouver. Wearing HMDs, multiple users can have a shared experience using their preferred interface (leaning-based or hand-held controller), ensuring accessibility for users not able to stand, or preferring to sit. In VR, users will see each other's avatar (see Fig. 1, middle picture). Users will be able to immerse themselves into this experience, described by numerous pilot testers as "intuitive to control", "empowering", "easy to learn without any instructions", and "not nauseating at all".

[1]The Virtual Vancouver model is provided by GeoSim Cities Inc.

4 CONTRIBUTION, CONCLUSIONS & FUTURE WORK

HyperJump provides a simple yet effective way to reduce motion sickness by adjusting the threshold velocity where jumps are added to the continuous locomotion. This can be done in real-time in VR (by pressing A/B button on controller), or prior to entering VR by pre-setting the threshold. Based on user profiles/preferences and motion sickness susceptibility, the thresholds vary from “hardcore”, to high susceptibility (where anything beyond walking speeds might be nauseating). We are currently exploring ways to automatically adjust HyperJump thresholds based on user's physiological parameters (e.g., eye tracking, body sway) and environmental parameters (e.g., increasing jump velocity thresholds for large-scale/outdoor navigation when potential obstacles are further away, and/or optic flow is lower). Through elimination of motion sickness, and support for the presence and plausibility aspects of VR, we aim to contribute a navigation paradigm that goes beyond 'enjoyable VR', and towards breathtaking, awe-inspiring VR. In order to achieve these profound experiences, it is necessary to remove the hindrances of motion sickness, unintuitive navigation and limited agency in the environment. The resulting empowerment and meaningful interaction are part of achieving the lofty goal of VR as a truly transformational technology, and experience.

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