Can We Give Seated Users in Virtual Reality the Sensation of Standing or Even Walking? Do We Want To?

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ABSTRACT

VR is often experienced in a seated position, similar to 3D video games, that almost exclusively are. The reasons for this are diverse and can go beyond just being more comfortable [18]. Interestingly, even when users are physically seated, often designers try to simulate standing and moving experiences, using head-bobbing and other ways to make users believe they are walking. Does this actually work? Can we get seated users to believe they are standing, walking, or even running? Moreover, is trying to provide the illusion of being standing or moving while being seated even relevant and helpful? Does it improve user experience or performance? Or might it be more effective just to be "honest" and ensure that the virtual locomotion metaphor matches the users' physical posture? In this extended abstract, we aim to explore these little-researched questions and analyze different situations and scenarios, hoping to help motivate future research and discussion on this topic.

1 INTRODUCTION

When not stationary, VR experiences itself divide into free-flying ones (including submersibles), usually supported by a 3- to 5-DoF travel technique [16], and ground-based ones (including ship/swimming simulations), usually supported by 2- or 3-DoF travel [4]. While seated flying in VR might insert seamlessly into our mental concepts or expectation, as users are typically seated when operating an airborne vehicle, such that being seated in VR matches the real-world situation [19], the case is more diverse in ground-based scenarios. Here the seated user can basically be faced with three situations, resulting in different types and degrees of the real world – VR (mis)match:

1. The VR also simulates a seated position, thus matching the user's actual seated posture, ideally minimizing any real-world - VR postural mismatch. Content creators can often pick a locomotion metaphor to match the users' physical posture - e.g., by using a wheelchair locomotion metaphor and seating users in an actual wheelchair [9], or a little bit less conventional, in front of a flying (office) desk [19].
2. The context in VR suggests or even requires the user to stand or walk. This obviously creates a postural mismatch between reality and virtuality, providing several options for the content creators:
   (a) try to make the users believe they are standing/walking
   (b) accept the mismatch. *However, what does that actually mean? The user will always try to create a mental model to reduce the mismatch and cognitive dissonance, e.g., by imagining being a dwarf or hovering. So, is (b) in the end the same as (a), but uncontrolled in the sense that it is up to the user to resolve the mismatch mentally or otherwise?*
   (c) reconsider the setting/metaphor and turn it into a standing application
   (d) explicitly give users the option to stand up as desired or advantageous (hybrid) and design for it. This could include providing both options to sit and stand up, and safe ways to switch as desired by the user.
3. The VR scenario is "neutral" and does not imply either a seated or upright stance. Again, we could provide users with hybrid options to sit/stand/move as desired, although providing a seated option for long-term usage and safety might often be desirable.

In this abstract, we will concentrate on the cases 2(a) and 3, and as a consequence, on the arising question:

2 CAN WE GIVE A SEATED VR USER THE SENSATION OF STANDING OR EVEN WALKING?

In first-person video games, where users are typically seated, it is common that their eye-height in the game is corrected to standing, their heads are bobbing and footstep sounds are added, supposedly to provide a compelling (walking) user experience. This partially is necessary to match the world's scale and serves realism, but is it also convincing? It looks like yes, or at least in part [5], and a phenomenon known as willing suspension of disbelief seems to help the designers here.

When VR designers trick the users, there are multiple sensory modalities they can use. Of these, the visual and auditory ones are the easiest and cheapest to simulate and thus most commonly utilized in VR and video games, as the VR engine fully controls these cues – even though they cannot directly provide interoceptive or proprioceptive cues and thus necessarily miss potentially essential aspects. Below we provide a brief overview of some of the options used (and sometimes investigated) that aim to provide sensations of being upright or walking/moving even when users are seated:

height (vision) Quite commonly the camera's viewpoint is set to a standing eye-height, supposedly in an attempt to provide the correct scale and a better overview. This introduces conflicts, and it seems to be more often negatively recognized by the users in HMD-based VR than in first-person (screen-based) video games.

head-bobbing (vision) The simulation of cyclic head movements while moving has in VR already been shown to improve the sensation of walking [5, 6] as well as the embodied sensation of self-motion (vection) [1, 8]

movement speed (vision) The travel speed affects users' perception, where one might expect that a constant and fast speed should feel more like hovering/flying, whereas cyclic and slower movements more like walking or running. But are these hypotheses true, and what happens when the movements get even slower?

airflow (wind) (tactile) There is mixed evidence whether providing airflow can enhance vection [11] or not [3], which may be explained by a relatively small effect size.

walking sounds (acoustics) The simulation of footstep sounds can also improve the experience and sensation of walking and self-motion [3, 5, 12], in both standing and seated users [5].

walking vibration (tactile) Similarly to acoustics, simulated ground vibrations can enhance the sensation of walking [2, 3, 5, 14].

walking virtual body (vision) What may be the effects of having a virtual body, especially virtual legs, that perform walking motions while we are traveling? Are these visible enough in the periphery

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to have an effect? And if so, is it supportive or strange? Or does it just destroy the illusion if there is a mismatch between simulated and actual posture and leg movements?

muscles activity (proprioceptive) It is possible to utilize related motion sequences to partially involve the same muscles and thus trigger the same brain regions to support the sensation of real walking, such as in seated walking-in-place [7, 16]. Could stimulating the corresponding muscles physically or electrically have similar effects?

stimulate vestibular system (vestibular) We can abstract walking even further and only provide minimal vestibular cues, such as in shake-your-head paradigms [13].

motion sequences (semantic linking) Could we use other body parts to enhance VR walking sensations, such as finger walking-in-place [15], hoping they might stimulate related brain regions, or at least provide a metaphorical mapping?

Despite all these approaches, the question of whether we can give stationary users a compelling sensation of walking is typically not directly addressed in the literature. However, implicit or indirect evidence tentatively suggests that this might be possible, at least to some extent [5]. Furthermore, walking sensations should improve the closer we get to a complete simulation [3], even though only future work will reveal to what extent this will be possible. And even then, some open questions might remain – e.g., can we create an illusion that holds even when the user stops helping us through their willing suspension of disbelief? Finally, even if we could - why would we even want users to believe they are standing or walking if they are not?

3 Why would we want to make users believe they are standing or walking?

Is it really relevant? Does it actually improve the user experience or performance if we try and give the illusion of walking despite sitting? Or are there alternatives?

One reason to provide a believable experience of standing/walking was already briefly mentioned above in option 2(b): If we do not, users tend to start building a mental model that explains potential mismatches on their own anyways, in an uncontrolled way, which might interfere with our design intent or interest in generating a consistent experience. So how do people interpret their simulate motion if they are not explicitly cued one way or the other? In a relative motion study that we conducted [17], seated participants had to travel through a non-branching roman temple maze at jogging speed, using joystick and body-leaning methods. When participants were later asked about their movement perception, 10 out of 19 explained it as hovering in a seated position, 4 as hovering in a standing position, 2 felt like a walking dwarf, and 3 were regularly walking. Thus participants' interpretations varied a lot, and one reason might be that we did not suggest or support any of these options explicitly. Interestingly, half of the participants felt as if they were standing in VR, even without us trying to make them believe (see Section 2).

Further reasons for trying to induce the illusion of walking could include trying to enhance realism, spatial orientation, distance estimation, perception of scale and overview, vection, or presence. But trying to provide a fully embodied and believable walking experience will likely still be expensive, even anticipating future technological improvements. And the benefits are not always clear – e.g., although users in some cases prefer a walking simulation over hovering [6], there is limited evidence that simulated walking actually enhances vection [2].

Do the advantages of physical walking, such as improved distance estimation and spatial orientation, remain if the user just has the illusion of walking? We tentatively propose that this might indeed be the case, as the mere illusion of self-motion (circular vection) has been shown to facilitate perspective switches and thus spatial orientation, similar to actual self-motion [10]. This suggests that a compelling illusion can indeed have behavioral relevance and functional significance while also reducing the need for physical locomotion. Depending on the actual application and desired user experience, the compelling sensation of being in and moving through the VE might end up being more important than believing that one is walking. That is, when constraints dictate a seated user experience, it might be more effective just to be *honest* and use a seated VR locomotion metaphor whenever feasible, such as a scooter or wheelchair [9]. Or, if feasible, design for a hybrid solution 2(d), where users can choose to sit or stand up, supported by a suitable movement metaphor.

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