Space Walk: A Combination of Subtle Redirected Walking Techniques Integrated with Gameplay and Narration

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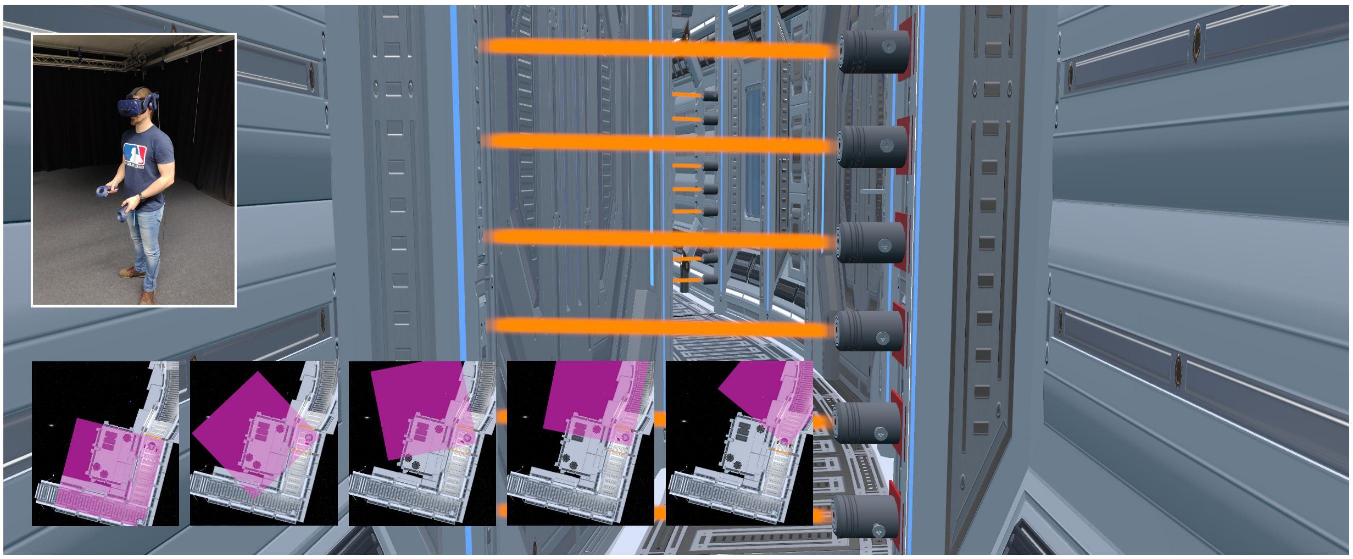

Figure 1: Illustration of an interaction task which is integrated within a rotation gain: The user (top left inset) has to move each laser beam (background image) from one wall to another while the virtual environment is turned around him (bottom).

ABSTRACT

Redirected walking (RDW) denotes a collection of techniques for immersive virtual environments (IVEs), in which users are unknowingly guided on paths in the real world that vary from the paths they perceive in the IVE. For this Emerging Technologies exhibit we present a playful virtual reality (VR) experience that introduces a combination of those RDW techniques such as bending gains, rotation gains, and impossible spaces, which are all subtly integrated with the gameplay and narration to perfectly fit the given environment. Those perceptual tricks allow users to explore a virtual space station of $45m^2$ in a room-scale setup by natural walking only.

CCS CONCEPTS

• Computing methodologies → Virtual reality; **• Human-centered computing → Virtual reality**.

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1 INTRODUCTION

Locomotion is still one of the most challenging interactions in VR. There is a lot of evidence that natural walking is the ideal locomotion technique regarding criteria like presence, VR sickness, wayfinding, spatial cognition, or usability [Langbehn and Steinicke 2018]. However, natural walking in VR is limited by the available physical space surrounding the user.

RDW enables natural walking in confined spaces by manipulating the user's visually perceived path [Matsumoto et al. 2016; Suma et al. 2015]. For instance, the user could experience a virtually straight path while actually walking in circles in the real world [Langbehn and Steinicke 2018]. Up to certain detection thresholds, such manipulations remain unnoticeable [Steinicke et al. 2010]. Several different redirection techniques have been proposed during the last 15 years [Langbehn and Steinicke 2018], e. g., curvature gains, rotation gains, impossible spaces, or distractors.

However, the previous approaches to RDW often focused on finding generalized solutions for unlimited walking in VR which can be used in any IVE - with only limited success. For instance, algorithms like steer-to-center or steer-to-orbit try to keep the user inside the walkable space [Razzaque 2005], but they work only for large tracking spaces and even cannot guarantee that the user does not hit the boundaries. Hence, such issues especially occur in small, so-called room-scale, VR setups [Azmandian et al. 2015]. Therefore, reorientation phases are necessary, which turn the user back to the walkable area. Often, these phases are not subtle and induce a break of presence in the user. The high sense of presence, which is supposed to be correlated with natural walking in IVEs, is impaired.

2 THE SPACE WALK EXHIBIT

In this Emerging Technologies exhibit, we present a completely new approach that couples the redirection techniques directly to the IVE, without using generalizing algorithms, and integrates them with other interactions, gameplay, and narration. The exhibit integrates three different redirection techniques: (i) bending gains [Langbehn et al. 2017], (ii) rotation gains [Steinicke et al. 2010], and (iii) impossible spaces [Suma et al. 2012]. These techniques are applied at specific locations and moments in the IVE (see Figure 2). The complete VR experience has a connecting narrative that blends together the science fiction setting and the interactions. When the user dons on the HMD and starts the experience, she is transported as astronaut into an abandoned space station. Her mission is to explore the station, which includes simple puzzles and tasks. The above mentioned redirection techniques are subtly integrated with those tasks. For instance, during the experience, a laser barrier is in the middle of a corridor and blocks the user's way (see Figure 1). Hence, the user needs to unmount the laser beams and attach them to the other side of the corridor. This task requires turning back and forth several times. At this point, we apply rotation gains which allows us to rotate the user virtually more than physically. After all laser beams have been moved to the other side, the whole IVE is rotated around the user and spaces that were not in the walkable area before can be explored now (see Figure 1 insets).

In total, an area of $45m^2$ in the virtual space station can be explored in a VR tracking space of $4m \times 4m$. A strength of our approach is that this area can easily be extended by just integrating more instances of redirection techniques into the virtual environment.

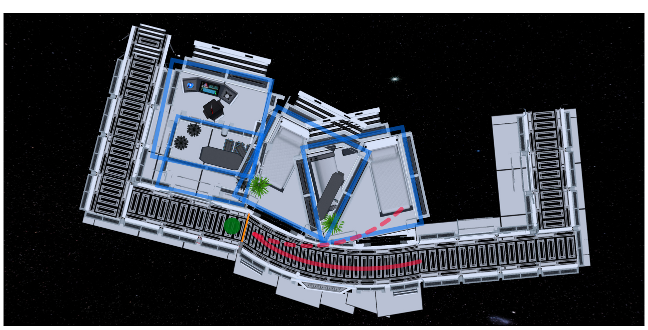

Figure 2: An overview of the environment and its integrated redirection techniques: impossible spaces (blue rectangles), bending gains (red lines), and rotation gains (green point).

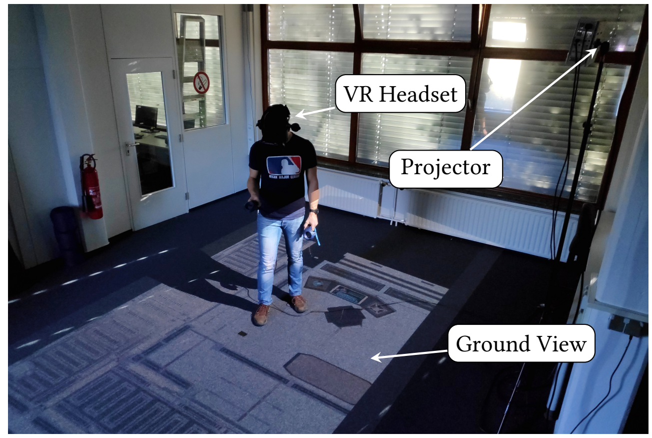

Figure 3: The observer view: An orthogonal top-down view of the virtual environment is projected to the ground.

Furthermore, in order to present the RDW walking techniques also for bystanders, we include a novel way of presenting the redirection techniques by projecting a top-down view of the IVE to the ground under the VR user (see Figure 3).

3 CONCLUSION

Instead of developing RDW algorithms that want to fit all kind of environments but fail for room-scale VR, our approach fits perfectly for one environment without disrupting the flow of the VR experience. Thus, VR creators may already think about RDW integration when designing levels, gameplay, story, and interactions. This approach might be interesting especially for VR arcades, VR escape rooms, or VR theme park rides.

In the future, we will bundle the used redirection techniques in a toolkit and make it available to developers.

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