

# Designing Intentional Impossible Spaces in Virtual Reality Narratives: A Case Study

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## ABSTRACT

Natural movement and locomotion in Virtual Environments (VE) is constrained by the user's immediate physical space. To overcome this obstacle, researchers have established the use of impossible spaces. This work illustrates how impossible spaces can be utilized to enhance the aesthetics of, and presence within, an interactive narrative. This is done by creating impossible spaces with a narrative intent. First, locomotion and impossible spaces in VR are surveyed; second, the benefits of using intentional impossible spaces from a narrative design perspective is presented; third, a VR narrative called *Ares* is put forth as a prototype; and fourth, a user study is explored. Impossible spaces with a narrative intent intertwines narratology with the world's aesthetics to enhance dramatic agency.

**Keywords:** Human-centered computing, Virtual Reality, Interaction design theory, design.

**Index Terms:** I.3.7 [Three-Dimensional Graphics and Realism]: Virtual Reality

## 1 INTRODUCTION

Virtual reality's (VR) increased capacity for robust interactions has provided the opportunity for interactive narrative designers to create immersive worlds that defy a user's sense of immediate physical reality. Interaction designers for VR narratives can utilize room-scale VR systems, such as the HTC Vive, to guide users through a story's setting. However, supporting natural locomotion throughout a VE is not yet practical. High-end consumer systems provide a maximum tracking area of about 4m x 3m—a tight container for VEs that, at their true scale, can span hundreds to thousands of meters. Temporary navigation solutions such as teleportation, gaze-directed locomotion, and gesture-initiated movement exist [1]. However, each solution detracts from the user's sense of presence in the story and stifles its believability [6]. As such, we present a design framework for an interactive narrative that bypasses presence-breaking navigation techniques for expansive VEs in room-scale VR. The impossible space design mechanic [7] which uses non-Euclidean geometry and perceptual illusions, is employed to facilitate natural locomotion in room-scale VR, specifically within an interactive narrative. A collection of previous work is reviewed before turning to the design of impossible spaces with narrative intent. Intentional impossible spaces are a slight augmentation to the original concept and focus

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on designing from a particular intent, in this instance the setting and context of a story, to make belief in the VE [4].

## 2 LOCOMOTION IN VR

There are a number of potential solutions for locomotion in expansive VEs [1, 7]. These efforts can be classified on an Interaction Fidelity scale [8]. On the low-fidelity end are those solutions that utilize super-natural powers; a magical approach, such as teleportation and non-natural tactics, and an engineering approach, such as building a physical space that matches the specific structures of a VE. On the other end of this scale is natural-locomotion with high interactive fidelity. The work of Suma et al. (2012) marks a forward leap in attaining truly natural locomotion. Impossible space design focuses on the user's perception of the setting and their movement there within [7]. By building on this previous research through a narrative lens, we position the user in a seemingly natural story world that responds contextually to their interactions and facilitates high-fidelity natural locomotion.

### 2.1 Impossible Spaces

Impossible spaces represent an architectural illusion that maximizes the virtual area users can explore through natural locomotion. Most importantly, the user's perception of space remains consistent when exposed to these illusions. This can reorient users away from the boundaries of their physical location without for a seamless VR experience. Such spatial architecture empowers VR narrative designers to build story worlds with real depth and believability. As users move freely throughout the space and begin to understand its characteristics, affordances, and setting, it becomes the place for performing belief and action within the narrative [9].

Current efforts to employ natural-locomotion in VR are often designed from a technical perspective and ignore a setting's environmental affordances beyond its architecture. This stymies the development of believable narratives as the physical structure of the story world is prioritized above the setting's narrative opportunities. Intentional narrative framing weaves together these opportunities for expressive interaction with the virtual setting. The immediate benefit of this is that it enables a greater degree of potential engagement with the story world and thus increases a user's sense of dramatic agency [5].

## 3 INCREASED NARRATIVE IMMERSION VIA IMPOSSIBLE SPACES

Designers can be empowered to embed the characteristics of their story worlds within the structure of their VEs. Overlapping physical structures may break Euclidean geometries, but the illusion of their architectural integrity can be enhanced by behaviour contextual to the narrative's setting. Utilizing an aesthetic that affords a range of natural interactions increases the believability of the VE [3]. For example, a narrative that takes place in a sprawling winter tundra might use a snow storm as part of an architecture of the VE to direct a user's movement [2]. While rendering a whitish-blue wall of ice

may also be effective, contextual environmental events increase tension in the story without interrupting the user's sense of presence. Orchestrating natural events within intentional impossible spaces increases immersion in the experience.

#### 4 ARES: A TEST CASE

Ares is a VR thriller being developed by an interdisciplinary cohort of graduate students at the Georgia Institute of Technology. Users begin the experience onboard the International Space Station where they are told that they've just won their own reality TV show in space, funded by a private corporation. Just as they blast off, the navigation fails and the user crash lands in a subterranean cave on an unknown planet. It's a race against the clock to navigate to the surface before oxygen runs out. This VR narrative contains three large cave rooms that are linked together by wending caverns and crawlspaces. The user is able to use natural locomotion to navigate the entire experience.

##### 4.1 Impossible Spaces in Ares

Ares' cave-like aesthetic facilitated the design of impossible spaces that uses natural events like those mentioned above to direct a user's movement away from physical boundaries. As users move from the first room to the second, their vision is blocked by cave walls. During this transition, a new space is rendered 'behind the scenes' and falling rocks prevent user movement unwanted by the designer. This new space has a maximum 50% overlap with the first room. The narrow transition pathway was designed to redirect users away from the physical boundaries of the play space while remaining consistent with the narrative's setting (e.g. narrow crevasses in caves). A similar transition happens between the second and third rooms (Fig. 1).



Figure 1: Overhead diagrams of the overlapping architecture in Ares. White paths indicate user movement. Solid circles indicate trigger areas where scene manipulations occur.

##### 4.2 User Study

Three participants were in our study, 2 males and 1 female, between the ages of 22 to 25. All three participants had used an HMD VR system within a week prior to the study.

Participants started out in the first cave room of the Ares narrative, and were told to explore and progress throughout a series of three cave rooms (Figure 2). In corner of the first room, we placed a large landmark. During the transitions between rooms, the architectural layout was manipulated as discussed above to create the subsequent rooms. After participants reached the third room, they were asked to point in the general direction of the landmark, and we recorded the response as either correct or incorrect. Participants were then told to remove the headset and were interviewed regarding the believability of the space using questions from [7].

All participants correctly estimated the direction of the landmark. In short, participants were able to maintain a consistent mental map of the virtual space. Moreover, all mentioned that throughout the experience, they did not feel lost nor did they notice anything unnatural about the virtual space. One participant however, a heavy gamer and herself a developer of VR experiences, was able to deduce the architectural manipulation post hoc. The



Figure 2: A user moves freely in the Ares experience triggering an architectural change in the impossible space.

other participants understood the impossible space concept during the post-interview debrief, and mentioned that it did not negatively affect their experience.

Throughout the study, participants' sentiments seemed to echo those from [7]. For example, all three vocalized that the experience felt like a maze. However, this is beneficial for establishing immersion. As caves are generally expected to be confusing to navigate, the intentional application of the impossible space mechanic improved the narrative's aesthetic.

#### 5 CONCLUSION

These initial findings suggest that intentional impossible spaces are an effective tool to enable natural locomotion within expansive VR narratives. Truly immersive worlds can be achieved when these spaces are used in conjunction with aural and visual feedback and contextual environmental events. As such, VE designers might consider additional ways in which movement through intentional impossible spaces greatly increases the capacity for interactions within their narrative worlds. Future work concerns creating impossible spaces that are modeled off of avant-garde found theatre productions and conducting more evaluations on presence in VR.

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