Enhancing Proxy Localization in World in Miniatures Focusing on Virtual Agents

Andrea Bönsch[‡], Radu-Andrei Coanda[*], and Torsten W. Kuhlen[‡]

[‡] RWTH Aachen University
Visual Computing Institute
E-Mail: boensch|kuhlen@vr.rwth-aachen.de

[*] RWTH Aachen University
Department of Computer Science
radu.coanda@rwth-aachen.de

Abstract: Virtual agents (VAs) are increasingly utilized in large-scale architectural immersive virtual environments (LAIVEs) to enhance user engagement and presence. However, challenges persist in effectively localizing these VAs for user interactions and optimally orchestrating them for an interactive experience. To address these issues, we propose to extend world in miniatures (WIMs) through different localization and manipulation techniques as these 3D miniature scene replicas embedded within LAIVEs have already demonstrated effectiveness for wayfinding, navigation, and object manipulation. The contribution of our ongoing research is thus the enhancement of manipulation and localization capabilities within WIMs, focusing on the use case of VAs.

Keywords: Proxy Localization, World in Miniature, Virtual Agents, Social VR

1 Introduction

To enhance immersion and realism in LAIVEs, VAs are often introduced to simulate social interaction within these communal spaces and represent direct interaction partners, providing, e.g., knowledge or support for subsequent user tasks. However, efficiently locating and interacting with them in large complex settings pose challenges due to the expansive virtual space and visual clutter, complicating also effective selection and manipulation of the VAs. Additionally, the challenge of locating these VAs is further increased by their dynamic nature, as they can freely traverse the LAIVEs without predictable patterns, in contrast to static scene geometry or dynamic geometry, which is often location-bound or has predefined motion (e.g., opening/closing doors or cars moving along predefined paths).

One approach to address the complexities of LAIVEs is the WiM [SCP95, DEJW21]. It provides a scaled-down duplicate of the virtual scene (Fig. 1), offering flexibility in exploring specific scene extracts through translation, scaling, and rotation [TVM20, BFK16] and effective occlusion management techniques [TAA09, BFK16]. Beyond visual exploration, users can also conveniently access and manipulate scene objects through their proxies in the WIM.

An underexplored challenge, however, involves the localization of these proxies. Thus, our work-in-progress focuses on developing a proxy localization system, tailored to the use-case of VAs. An efficient localization of VAs facilitates direct user-agent interactions and enables users to orchestrate the VAs for an interactive and enhanced experience. By combining

Figure 1: Our WiM setup with four interface elements located on the WIM's exterior: a *WiM options panel* (1) for general control, an *overview panel* (2) offering a list of all VAs and an individual localization option, and a *temporary storage box* (3) and an *agent panel* (4) for VA orchestration.

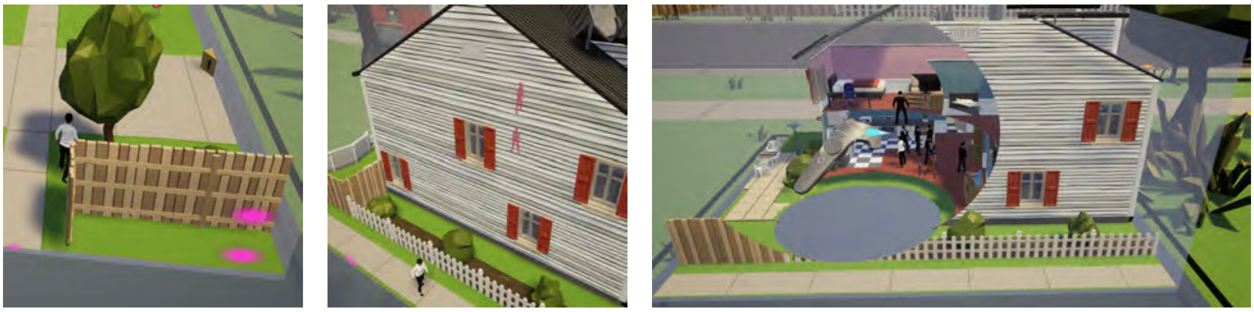
WIMs and VA interaction for greater user control, we seek to advance user experiences by improving social interactions and user engagement within VR environments in the long term. Here, we only focus on the first features of our localization system.

2 VA Localization and Manipulation

Challenges in determining the availability and locations of VAs due to the scale and cluttered nature of LAIVES hinder efficient interactions and orchestration within the virtual environment. Users may, e.g., face difficulties in engaging with specific agents, limiting their VR experience or hampering subsequent task execution. To this end, our WIM is enhanced by different proxy localization techniques combined with a simple orchestration option.

General WIM Setting Our WiM (Fig.1) replicates the scene, including the VAs and their animation loops, preserving both shape and dynamic behavior from their full-scale counterparts. Scene extract manipulation employs similar scaling and panning techniques as presented in [TVM20]. However, the main focus of our work lies in the development of proxy localization techniques and orchestration options. For this purpose, we integrated four panels along the exterior of the WiM (Fig. 1). Panels 2 to 4, detailed below, are dedicated to direct proxy (here VA) localization and manipulation within LAIVEs. Panel 1, the *WiM options panel*, allows users to (i) center the view volume on their current location, (ii) lock the WiM to avoid accidental interactions, (iii) toggle the agent *overview panel* (panel 2), and (iv) trigger occlusion management features.

Proxy Overview To enable informed decisions and prevent user frustration arising from searching or missing relevant VAs, a quick overview of all available VAs is required and a



(a) (b) (c)

Figure 2: (a) Magenta indicators directing users to a nearby proxy VA; Occlusion management by (b) highlighting all occluded proxies and (c) "melting walls" [TVM20] while keeping the proxies.

quick localization of specific proxy VAs. To this end, we provide an *overview panel* (panel 2, Fig. 1) listing all VAs, while presenting essential, predefined, information such as their names and roles. Additionally, a button enables efficient localization of the respective proxy, allowing users to effortlessly center their WIM view on the selected VA.

Supported Naive Search Besides localizing specific VAs, users may require to quickly find nearby VAs avoiding unnecessary delays or distractions for a smoother experience. To this end, we support naive search by including magenta indicators placed at the base of the view volume (Fig. 2a). The indicators display the direction of the nearby proxies, effectively guiding users in the right direction. This feature furthermore enhances user convenience, enabling efficient exploration and engagement with the VA.

Occlusion Management To address the challenge of obstructed proxy VAs, which can be hidden despite being within the WIM's view, we introduce two techniques: (i) We extend the x-ray technique (cp., [BFK16]) to dynamic objects, highlighting the silhouettes of the proxy VAs against static geometry (Fig. 2b), ensuring that users can clearly discern the presence of proxy VAs within the scene extract. (ii) We employ the cutting shapes occlusion management technique [TVM20]) to selectively render overlapping parts of the miniature scene invisible while maintaining the visibility of the proxy VAs (Fig. 2c), enabling users to peek inside buildings providing a better view onto the proxies.

Proxy Orchestration To allow more interaction flexibility and assessment of the VAs, users shall easily reposition them. Orchestration is limited to (i) proxy rotations around its vertical axis and (ii) movements in the horizontal plane, aided by a snapping feature that automatically places the proxy on the nearest walkable ground. A temporary storage box (panel 2, Fig. 1) is provided for the proxy while updating the displayed scene extract in the WIM during greater movements. Confirming the new proxy position in the agent panel (panel 4, Fig. 1) either teleports the VA or allows it to walk to the new location. Furthermore, the panel offers the option to teleport the user to the VA for quick direct interactions.

3 Preliminary Insights

In a small first feasibility study, 6 participants (5 males, age: M=26.83 ± 6.3) learned about the WiM's features and independently completed localization and manipulation tasks. The results were promising, with participants intuitively navigating the controls and executing the tasks. However, participants encountered challenges when interacting with the proxy VAs. Especially when the scene extract shown in the WIM was zoomed out too much, the proxies were too small causing interaction issues.

4 Conclusion

We presented a WiM approach for proxy (here VA) localization and manipulation in LAIVEs. Preliminary results of a feasibility study were promising. The next step is to extend the proxy localization options, e.g., highlighting all proxy VAs with the same knowledge, required, e.g., for the next task. Furthermore, we want to refine the current interaction patterns, e.g., scaling up the WIM's view volume or selected proxy VAs may enhance interaction precision and thus help to overcome current challenges. A comparison study between different VR object localization options shall then identify the efficient techniques.

References

[BFK16] Andrea Bönsch, Sebastian Freitag, and Torsten W. Kuhlen. Automatic Generation of World in Miniatures for Realistic Architectural Immersive Virtual Environments. In *2016 IEEE Virtual Reality (VR)*, pages 155–156. IEEE, 2016.

[DEJW21] Kurtis Danyluk, Barrett Ens, Bernhard Jenny, and Wesley Willett. A Design Space Exploration of Worlds in Miniature. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 2021.

[SCP95] Richard Stoakley, Matthew J. Conway, and Randy Pausch. Virtual Reality on a WIM: Interactive Worlds in Miniature. In *Proc. of the SIGCHI Conference on Human Factors in Computing Systems*, pages 265–272. ACM Press, 1995.

[TAA09] Ramón Trueba, Carlos Andujar, and Ferran Argelaguet. Complexity and Occlusion Management for the World-in-Miniature Metaphor. In *Smart Graphics*, volume 5531, pages 155–166. 2009.

[TVM20] Samuel Truman and Sebastian Von Mammen. An Integrated Design of World-in-Miniature Navigation in Virtual Reality. In *International Conference on the Foundations of Digital Games*, pages 1–9. ACM, 2020.