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VR-CrowdCraft: Coupling and Advancing Research in Pedestrian Dynamics and Social Virtual Reality

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VR-CrowdCraft is a newly formed interdisciplinary initiative, dedicated to the convergence and advancement of two distinct yet interconnected research fields: pedestrian dynamics (PD) and social virtual reality (VR). The initiative aims to establish foundational workflows for a systematic integration of PD data obtained from real-life experiments, encompassing scenarios ranging from smaller clusters of approximately ten individuals to larger groups comprising several hundred pedestrians, into immersive virtual environments (IVEs), addressing the following two crucial goals.

1 Advancing Pedestrian Dynamics Analysis

The first goal, and focus of this late-breaking report, is to extend the methodological toolbox for PD analysis through a VR-based approach. This involves orchestrating virtual agents (VAs), which represent the pedestrians, to precisely align with collected PD data from real-life experiments to replicate the intricacies of the observed real-life situation in the IVE as closely as possible. The resulting visualization is then subject to in-depth analysis by PD experts.

Despite the endeavor's significance, a research gap exists in 3D visualization tools tailored for (VR-based) pedestrian behavior analysis. Simulations using experimental PD data are specific instances within the broader category of general crowd simulation frameworks. These frameworks rely on algorithms developed through theoretical or mathematical approaches or informed by real-world observations. Diamanti [5, Table 2.13] notes these frameworks, like Menge[1], often provide limited visualizations, requiring proprietary and advanced visualizers [3] (see Fig. 1). Thus he advanced his Agora framework with a Unity-based visualizer [5]. Besides, the frameworks primarily offer evaluation techniques for comparing simulation results with real-world data [5, Section 2.2.6]. In commercial tools like Legion[2] or Pathfinder[3], VR integration is occurring, but the fusion of visualization with analysis features remains rare. An exception are Mayo et al.'s Unity tool [7], showcasing practical application by successfully combining visualization and analysis features.

We aim to address this research gap through a VR-based visual analysis framework focusing on in-depth locomotion data analysis. This includes parameters like pedestrian position, body orientation, walking speed, as well as psychological and physiological metrics. Crowd exploration will be enhanced by flexible VA representation like wooden mannequins or anthropomorphic characters, interactive elements like trajectory displays or time navigation. Furthermore seamless switches between exocentric and egocentric perspectives allow users to place themselves in the crowd at different points and study perception depending on the surrounding VAs.

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[1] http://gamma.cs.unc.edu/Menge/
[2] https://www.bentley.com/software/legion/
[3] https://www.thunderheadeng.com/pathfinder

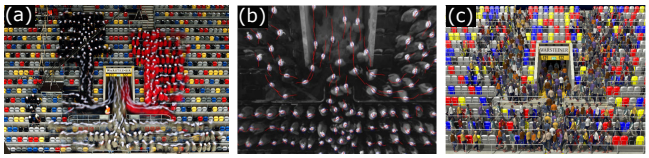

Figure 1: PD experiment in Esprit-Arena Düsseldorf: (a) Photo of the stadium with pedestrians, (b) data collected during pedestrians leaving the stadium, (c) rendering[4] of the experiment replicated in Menge, visualized with a proprietary visualizer (taken from [1–3]).

2 Advancing Virtual Pedestrian Behavior: Authentic Populated IVEs & New PD Experiments

The second goal aims to improve the design of VAs by incorporating authentic, situation-dependent reactions extracted from PD data into populated IVEs. This ensures a dynamic and responsive virtual encounter, enriching the overall user experience. Furthermore, it allows to unveil insights into how specific VA behavior influences users' reactions and perception of (social) presence within the IVE. Additionally, it enables new PD experiments within VR, to study complex social interactions such as the adaptation of personal space to the situation or the joint formation and maintenance of a queue. This is possible as previous research demonstrated alignment between participants' behavior in VR and real-world norms [4], while potential smaller effect sizes may occur [6].

References

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[4] for a video see: https://youtu.be/aiw1ifGqTF0