International Cartographic Association
Association Cartographique Internationale

A comparison of virtual reality locomotion techniques in indoor environments

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Keywords: virtual reality, locomotion, indoor, user study

Abstract:

Locomotion in virtual reality is one of the important aspects of building an immersive virtual environment. It is necessary to provide a means to navigate the environment for the user. It can be achieved by using a variety of hardware devices as well as different software methods.

Virtual locomotion can be categorized by several criteria. Boletsis (2017) propose a classification of the locomotion techniques into four distinct groups. *Motion-based* techniques use the physical movement of the user to enable locomotion and/or interaction in the environment typically using a continuous movement. *Room scale-based* techniques are similar to motion-based but aim to use the real walking of the user for navigation in the environment. Because of this, the dimensions of the virtual environment are bounded to the physical space user is in. *Controller-based* techniques use an artificial controller to enable the continuous movement of the user. Finally, *teleportation-based* techniques also use a controller, but the movement of the user is realized in discrete jumps. All of these types have their benefits and disadvantages.

Even though the research on different virtual locomotion methods has gained momentum. Not all aspects of them have been studied, especially regarding their usability in different virtual environments. One of the specific types is *an indoor environment*. It can be defined by its enclosedness as it presents limited space with defined borders (usually represented as walls), that not only prevent free (direct) movement but also limits visibility in the environment. Indoor also has its specifics when it comes to verticality and moving between different vertical levels (floors). The virtual environments of this type are for the purpose of this study called *virtual indoor environments (VIEs)*. VIEs can be in a broader sense also perceived as a combination of indoor cartography, virtual reality and building information model (BIM) as BIM can be one of the primary sources for building such an environment. With the addition of virtual reality to provide a way to interact with such environments, movement is one of the important aspects of the VIE. The combination of unique characteristics of the VIEs and the different locomotion methods however has not been fully studied so far.

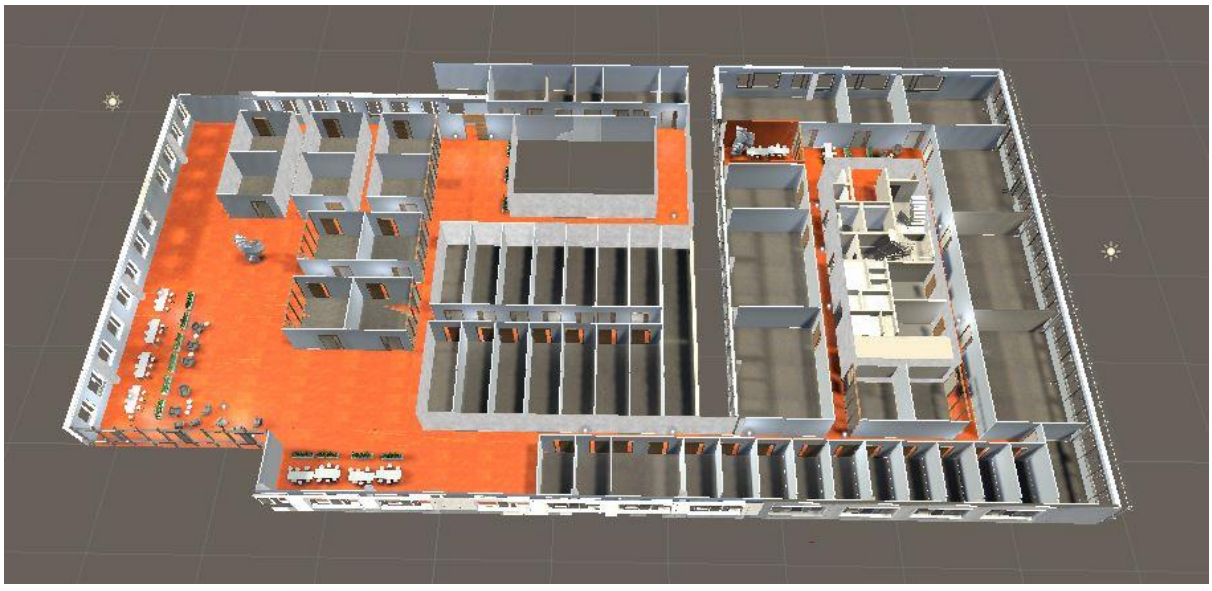

Figure 1. The virtual model of a floor used in the study

Abstracts of the International Cartographic Association, 5, 2022.
European Cartographic Conference – EuroCarto 2022, 19–21 September 2022, TU Wien, Vienna, Austria.
https://doi.org/10.5194/ica-abs-5-93-2022

To address this topic, an experiment in such an environment with three different locomotion methods is proposed. It will use an environment created by De Cock (2022) representing one floor of a fictive building (Figure 1). To have a variety in the types of locomotion methods, especially regarding the artificial vs. natural movement and continuous vs. non-continuous types, these methods will be used: *teleportation* (artificial, non-continuous), *controller* (artificial, continuous), and *walking-in-place* (natural, continuous). The study won't be using a *real walking* method (representing room scale-based methods). To address the differences between the locomotion methods, the used environment will be large scale (i.e. several rooms and corridors) as exploratory experiment showed, that less complex environments are not highlighting well specifics of the used techniques. However, the real walking technique needs a real physical environment with the same dimensions as the virtual one. That is technically and financially challenging when using a building/floor-scaled environment and therefore not a very used technique in this context. Navigational tasks will be provided for the user to motivate them to explore and move in the environment. During the experiment, their position will be monitored as well as their trajectories and time to get to the navigation targets. Other methods to determine how the navigation of the user in the VIE as well as their spatial cognition depending on the used locomotion techniques is affected will be used (i.e. mental rotations tests, semi-structured interviews).

The proposed study is a work-in-progress and preliminary (or final) results will be presented at the EuroCarto 2022 conference if it will be admitted.

Acknowledgements

The environment used in the proposed study was provided by Dr. Laure De Cock from Ghent University.

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