*Virtual Reality at 1:1 Scale in Small Physical Spaces*

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# ABSTRACT

Virtual Reality (VR) leads to the highest level of immersion if presented using a 1:1 mapping of virtual space to physical space—also known as *real walking*. The advent of inexpensive consumer virtual reality headsets, all capable of running inside-out position tracking, has brought VR to the home. However, many VR applications do not feature full real walking, but instead, feature a less immersive space-saving technique known as *instant teleportation*. Given that only 0.3% of home users run their VR experiences in spaces more than 4m², the most likely explanation is the lack of the physical space required for meaningful use of real walking.

In this thesis, we investigate how to overcome this hurdle. We demonstrate how to run 1:1-mapped VR experiences in small physical spaces and we explore the trade-off between space and immersion.

(1) We start with a space limit of 15cm. We present *DualPanto*, a device that allows (blind) VR users to experience the virtual world from a 1:1 mapped bird's eye perspective—by leveraging haptics.

(2) We then relax our space constraints to 50cm, which is what seated users (e.g., on an airplane or train ride) have at their disposal. We leverage the space to represent a standing user in 1:1 mapping, while only compressing the user's arm movement. We demonstrate our prototype *VirtualArms* at the example of VR experiences limited to arm movement, such as boxing.

(3) Finally, we relax our space constraints further to $3m^2$ of walkable space, which is what 75% of home users have access to. As well-established in the literature, we implement real-walking with the help of portals, also known as "impossible spaces". While impossible spaces on such dramatic space constraints tend to degenerate into incomprehensible mazes (as demonstrated, for example, by "TraVRsal"), we propose *plausibleSpaces*: presenting meaningful virtual worlds by adapting various visual elements to impossible spaces.

Our techniques push the boundary of spatially meaningful VR interaction in various small spaces. We see further future challenges for new design approaches to immersive VR experiences for the smallest physical spaces in our daily life.