Real World VR Proxies to Support Blind People in Mobility Training

Julian Kreimeier[1,2], Timo Götzelmann[1]

Nuremberg Institute of Technology, Keßlerplatz 12, D-90489 Nuremberg[1]

Technische Universität Dresden, Institute of Applied Computer Science, Nöthnitzer Straße 46, D-01187 Dresden[2]

{julian.kreimeier, timo.goetzelmann}@ohm-university.eu

Abstract

Mobility training is an essential part of blind people's education in order to move in public spaces. In order to safely learn new routes in public space, however, a seeing trainer must assist the blind person. With the increasing availability of VR hardware, it is possible to transfer real spatial environments to virtual representations. The digitized environments can be used as a basis for this training without safety problems by real world hazards. This allows to cope with the limited resources of sighted assistants and enables blind people to become more independent. We propose to capture real public spaces (such as sidewalks, train stations etc.) and make them in this way ascertainable. Orientation and mobility can be trained in this digital model via multimodal sensory feedback while involving intuitive locomotion and white cane exploration. This paper sketches the related work and proposes our novel approach. Furthermore, we suggest additional improvements on our ongoing research.

1 Introduction

Virtual Reality (VR) applications are currently experiencing a considerable revival. Among other things, this means that consumer devices are becoming cheaper and increasingly sophisticated. In the beginning, development concentrated mainly on the most important human sense, the visual perception. In the following, also other senses were given more attention. Special acoustic models have been developed for the most realistic simulation. Nowadays, consumer haptic interaction technologies are also being developed.

These VR systems are primarily designed for normal-sighted people. However, since the visual modality does not represent virtual reality on its own, there is a good chance that visually impaired people can participate from this technology through an adapted VR environment. For

Veröffentlicht durch die Gesellschaft für Informatik e. V. 2018 in
R. Dachselt, G. Weber (Hrsg.):
Mensch und Computer 2018 – Workshopband, 02.–05. September 2018, Dresden.
 https://doi.org/10.18420/muc2018-demo-0484

this purpose, spatial environments can be perceived using appropriate acoustic and haptic rendering.

People with visual impairments are dependent on mobility training if they want to move safely in public space. Usually individual routes have to be trained in advance. In this case, a seeing assistant is often necessary to help to learn a new route a couple of times. However, the resources of sighted assistants are limited. This dependence has a negative effect on the self-determination of blind people. Ideally, blind people could inform themselves in advance about a new route - including the spatial conditions. We present a novel approach that reproduces 3D environments captured with consumer hardware in a virtual environment for people with visual impairments. This interactive environment serves as platform to enable blind people to train independently and safely.

2 Related Work

In general, related work on VR environments for blind people can best be distinguished on the basis of the respective sensory feedback (Zhao et al., 2018). Due to the large number of previous works and the short scope of this demo paper, we would like to refer to the previously mentioned publication by Zhao et al. for an in-depth overview and the current state of the art. Therefore, we would like to concentrate on approaches very specific to our application.

Many of the work in this area uses auditory feedback to convey spatial information. In the context of ours, there is also one approach in which real spaces were synthetically modeled and training in them has significantly increased the subjects' mobility (Merabet & Sánchez, 2009). However, such approaches neglect haptic feedback and active, user-controlled exploration of the environment. Especially because navigation in the real world mainly takes place by means of haptic (via cane) and complementary feedback, there are also approaches that concentrate on this environmental perception. Most papers use miniaturized models (e.g. floor plans) which subjects can identify via a grounded controller providing haptic feedback (Lahav, Schloerb, & Srinivasan, 2015; Sánchez, 2012; Semwal, 2001). In addition to the aspect of multimodal feedback, the exploration and familiarization with an unknown environment can be also considerably improved through the optimization of each individual sensory modality, e.g. by differentiating virtual surfaces based on haptic feedback (Lecuyer et al., 2003). A few approaches even allow the blind user to move intuitively in the virtual world, i.e. she/he can in fact walk inside the virtual space as in reality (Tzovaras et al., 2009; Zhao et al., 2018). Nevertheless, all systems mentioned so far have a decisive disadvantage: Either the explorable area is very limited due to technical limitations or only synthetically modelled spaces (i.e., not real, public ones) are used. Furthermore, none of the VR approaches takes collaborative scenarios into consideration.

3 Approach

The capturing process is performed on-the-fly by hardware (such as Microsoft Hololens or Kinect) directly generating triangle meshes or by converting captured point clouds. To explore these real world VR proxy environments, users can freely move using a treadmill (see Figure 1). A tracked controller serves as virtual white cane, collisions of its tip with the environment are communicated by haptic and auditory feedback. This adapted way of exploration is intended to give blind people intuitive access to the virtual environment.

Optionally, a seeing assistant in a collaborative scenario can support the blind user from a remote computer. The achieved spatial independence of an assistant can help to obtain a greater availability and to implement crowd-sourcing strategies (such as the popular Be My Eyes) for VR applications. In addition, both blind users and assistants can integrate location-based verbal cues into the VR environment during the exploration.

Haptic feedback

Haptic feedback is made possible by a tracked off-the-shelf controller that simulates a virtual white cane. Collisions with the geometry of the VR proxies are communicated by vibration. In addition, force feedback is provided by physical computing components and actuators, which restrict the freedom of movement of the hand. This makes the interaction of the white cane with the virtual environment perceptible as a real force on the wrist.

More precisely, servomotors and wire rope hoists generate a force on the controller that corresponds to the collision of the virtual white cane. The VR Engine (Unity) sends commands to a microcontroller board via Wi-Fi, which controls the servomotors accordingly via PWM (Pulse Width Modulation) signals. Furthermore, the VR Engine can also directly control the vibration of the controller itself and thus generate haptic feedback.

Audio feedback

The auditory perception of the virtual environment is realized by spatial audio rendering (Google's *Resonance Audio*). This procedure allows the user to perceive the feedback of the white cane striking the VR scene as well as to receive location-based verbal comments from (previous) users or the assistant. This approach is also expected to be able to approximate the acoustics of buildings, which could be particularly beneficial for the trained hearing and therefore also orientation of blind people.

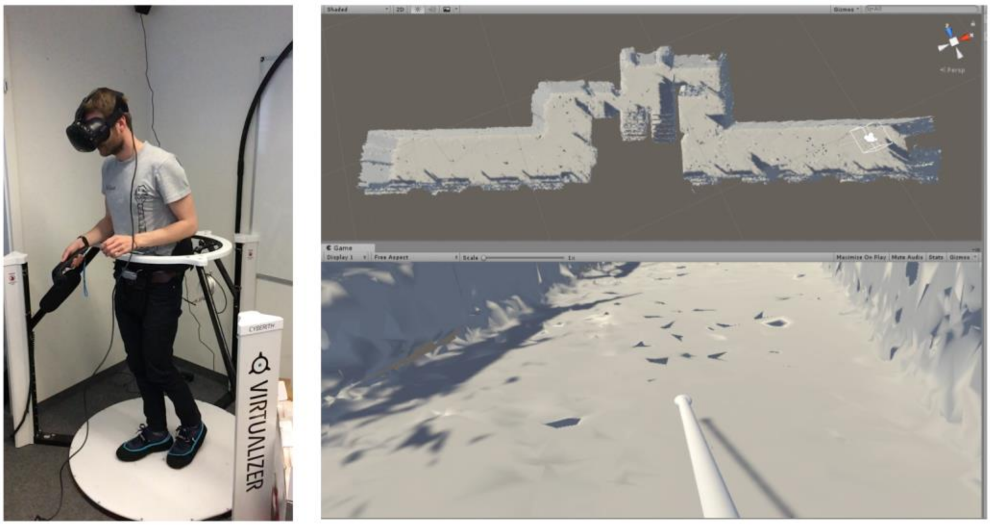

Figure 1: Test subject exploring model of real floor in virtual reality. Left: Real situation with subject walking inside the treadmill while holding the VR controller as 'virtual white cane'. Right: The parallel situation in VR, above the bird's eye view and below through the subject's VR glasses.

Collaboration

To make exploring and spatial learning of the VR proxy as easy and efficient as possible, we propose a collaborative user scenario. Thereby, the blind person is initially located in a static VR proxy using the aforementioned hardware. If necessary, a seeing trainer can join in and point out specific locations to the blind person using real time placeable audible points of interest (POI). These might say "Here is the door to my office" or "Watch out, this is where the ticket machine is located". Thus, the blind person can perceive both the contextual information and the spatial position. However, it is also thinkable that blind users can leave audible POI for each other to draw attention to these specific spots. For example, the automatically triggered audio feedback "Going further along this wall will lead you directly to the exit, I went there, too" when touching a wall appears quite helpful. In this context, a crowd-sourcing strategy can also be implemented in which seeing volunteers can (literally) look over the blind person's shoulder and provide information on context and space through their auditory feedback (as with the smartphone App '*Be My Eyes'* in reality). To make this likewise as easily accessible as possible, these volunteers might use smartphone-based VR systems such as Google Cardboard.

4 Conclusion and Future Work

In this paper, we presented a novel approach to make real world places (in particular public places) haptically perceivable to blind users through virtual environments. Using off-the-shelf 3D capturing hardware, no manual modeling of the VR proxy environment is necessary. In the subsequent process of this project, we are optimizing the transformation of real world data into the virtual scene, tweak the sensory feedback, and evaluate our approach in a comprehensive user study. In addition, we consider to what extent people with residual vision can have advantages (Götzelmann, 2018) through the visual representation of graphically abstracted environments.

References

Götzelmann, T. (2018). Visually Augmented Audio-tactile Graphics for Visually Impaired People. *ACM Transactions of Accessible Computing (TACCESS)*, *11*(2), 8:1-31. https://doi.org/10.1145/3186894

Lahav, O., Schloerb, D. W., & Srinivasan, M. A. (2015). Rehabilitation program integrating virtual environment to improve orientation and mobility skills for people who are blind. *Computers & Education*, *80*, 1–14. https://doi.org/10.1016/j.compedu.2014.08.003

Lecuyer, A., Mobuchon, P., Megard, C., Perret, J., Andriot, C., & Colinot, J. P. (2003). HOMERE: a multimodal system for visually impaired people to explore virtual environments. In *IEEE Virtual Reality, 2003. Proceedings.* (S. 251–258). https://doi.org/10.1109/VR.2003.1191147

Merabet, L., & Sánchez, J. (2009). Audio-based navigation using virtual environments: combining technology and neuroscience. *AER Journal: Research and Practice in Visual Impairment and Blindness*, *2*(3), 128–137.

Sánchez, J. (2012). Development of Navigation Skills Through Audio Haptic Videogaming in Learners Who are Blind. *Procedia Computer Science*, *14*, 102–110. https://doi.org/10.1016/j.procs.2012.10.012

Semwal, S. K. (2001). *MoVE: Mobiltiy Training in Haptic Virtual Environment*. https://pdfs.semanticscholar.org/243e/b3d64990f34d0b126b36132acc17e4f50737.pdf, accessed on 07/04/2018

Tzovaras, D., Moustakas, K., Nikolakis, G., & Strintzis, M. G. (2009). Interactive mixed reality white cane simulation for the training of the blind and the visually impaired. *Personal and Ubiquitous Computing*, *13*(1), 51–58. https://doi.org/10.1007/s00779-007-0171-2

Zhao, Y., Bennett, C. L., Benko, H., Cutrell, E., Holz, C., Morris, M. R., & Sinclair, M. (2018). Enabling People with Visual Impairments to Navigate Virtual Reality with a Haptic and Auditory Cane Simulation. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (S. 116:1–116:14). New York, NY, USA: ACM. https://doi.org/10.1145/3173574.3173690