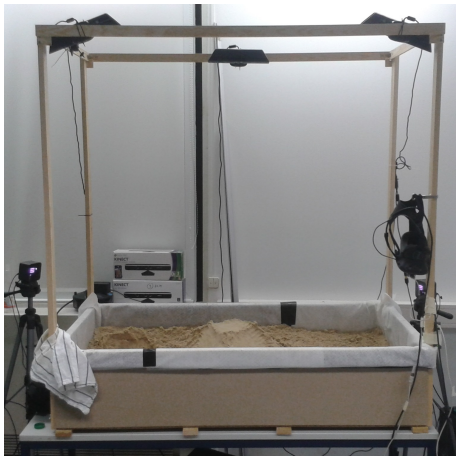

Figure 1: Setup of the VRBox. The sand is tracked with 3 depth cameras from the top. An HTC Vive is used for rendering. A Leap Motion attached on the HMD tracks the user's hands.

Demonstrating VRBox—A Virtual Reality Augmented Sandbox

Dmitry Alexandrovsky
University of Bremen
Bremen, Germany
dimi@uni-bremen.de

Tanja Döring
University of Bremen
Bremen, Germany
tanja.doering@uni-bremen.de

Susanne Putze
University of Bremen
Bremen, Germany
sputze@uni-bremen.de

Thomas Fröhlich
University of Bremen
Bremen, Germany
tfr@uni-bremen.de

Timo Stabbert
University of Bremen
Bremen, Germany
stormtibateb@gmail.com

Rainer Malaka
University of Bremen
Bremen, Germany
malaka@tzi.de

ABSTRACT

We present VRBox—an interactive sandbox for playful and immersive terraforming that combines the approach of augmented sandboxes with virtual reality technology and mid-air gestures. Our interactive demonstration offers a virtual reality (VR) environment containing a landscape, which the user designs via interacting with real sand while wearing a VR head-mounted display (HMD). Whereas real sandboxes have been used with augmented reality before, our approach using sand in

CHI'19 Extended Abstracts, May 4–9, 2019, Glasgow, Scotland UK

ACM ISBN 978-1-4503-5971-9/19/05.
https://doi.org/10.1145/3290607.3313251

Figure 2: External view on a user interacting with VRBox (top) and his view in the *tabletop perspective* mode. The user is performing a pouring gesture to place virtual objects in the environment.

VR offers novel and original interactive features such as exploring the sand landscape from a first person perspective. In this demo, users can experience our VR-sandbox system consisting of a box with sand, multiple Kinect depth sensing, an HMD, and hand tracking, as well as an interactive world simulation.

KEYWORDS

Augmented Sandbox; Virtual Reality; Gestural Interaction; Playful Interaction; Natural Materials; Tangible Interaction.

ACM Reference Format:
Dmitry Alexandrovsky, Tanja Döring, Susanne Putze, Thomas Fröhlich, Timo Stabbert, and Rainer Malaka. 2019. Demonstrating VRBox—A Virtual Reality Augmented Sandbox. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts (CHI'19 Extended Abstracts), May 4–9, 2019, Glasgow, Scotland UK*. ACM, New York, NY, USA, 4 pages. https://doi.org/10.1145/3290607.3313251

INTRODUCTION

Most people relate to playing with sand from their childhood days. This unstructured play opens room for experimentation, exploration, or cooperation and helps developing important skills like creativity, proprioceptive sensing, body and space awareness [5]. Natural materials like sand have also been investigated as part of interactive systems (c.f. [2]). These materials are used because they naturally offer rich multimodal feedback and often provoke emotional associations.

Whereas several research projects have explored sandboxes and its tangible affordances in augmented reality (AR) environments (e.g., [1, 8, 9]), using real sand as interaction material in VR is a novel and original approach. Similar to our VR approach, many AR sandboxes have been used for interaction with geographical phenomena [4, 7] and for playful terrain exploration and design [1, 8].

In our work, we combine real sandboxes with VR interaction and thus provide a novel and original system that explores natural physical materials in VR, gestural interaction, and teleporting in a terraforming use case. The VRBox system has been recently published as a full paper without system demonstration at CHIPlay 2018 [3], where it received an Honorable Mention, and, in an earlier version, in 2017 as a Workshop presentation at a national workshop [10]. VRBox has not been presented at a demonstrations track before, so CHI 2019 is the first scientific event where this work can be experienced hands-on.

THE VRBOX SYSTEM

Setup

The original sandbox, which was used in a previously conducted expert evaluation [3], has a volume of $140 \times 80 \times 30$ cm. The ground and the inner walls are covered with non-reflective cloth. Three Kinect

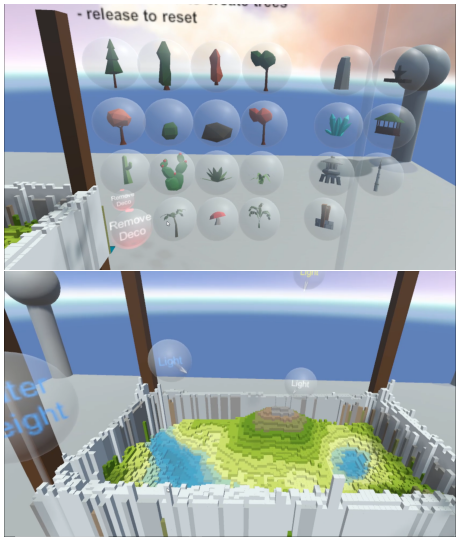

Figure 3: UI elements to adjust the environment settings (top) and a collection of assets that can be placed in the scene.

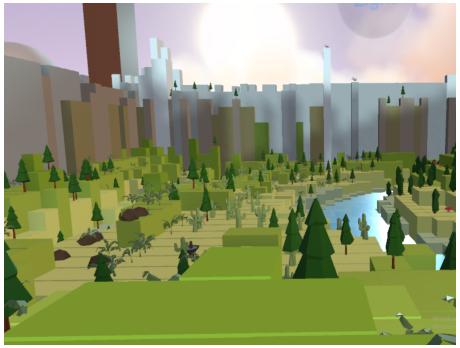

Figure 4: VRBox in *first person perspective*.

v1 sensors are mounted on a railing 120 cm above the sand surface and capture the tracking volume from three angles of an isosceles triangle. We use an HTC Vive as our VR platform. In additional, a Leap Motion sensor is attached to the HMD to track and visualize the user's hands. The setup runs in Unity3D on a desktop PC. The entire setup is shown in Figure 1.

In the VR application, the terrain is represented in a blocky Minecraft [6] like style on a 98×59 mesh with 32 height levels. This resolution provides a good compromise between level of detail and latency. To avoid the hands being mapped onto the terrain, we added a threshold at the top rim of the box. Everything above the rim is ignored by the Kinect sensors, and the area underneath the hands is marked as occluded. To increase performance, the terrain is split into chunks of 8 by 8 blocks. Only those blocks that have been occluded by the hands for a duration of at least 6 frames (100 ms) are updated. Since the incoming point cloud stream from the depth sensors is noisy, the height of each block is updated gradually at a rate of 10 Hz to avoid jittering. When a new height value for a block is provided by the sensors, the block is repositioned to that value, which takes up to 200 ms.

Application Scenario and Interaction

Our use case is a terraforming task where users form a 3D world of their liking with the sand and extend their creation by adding a water level to create rivers and other waters, add different lighting moods and decoration objects like trees, flowers, and castles. While standing in front of the sandbox and wearing an HTC Vive HMD, users can enjoy the haptic interaction in the sand and explore the corresponding landscape in virtual reality. Overall, they can interact with the sandbox in two modes: In *tabletop perspective* (Figure 2) and in *first person perspective* (Figure 4). In tabletop perspective, similar to AR sandboxes, users can sculpt the surface of the real sand and shape the terrain. Users can select virtual objects (e.g., plants or buildings) via mid-air gestures from a menu (see Figure 3, top) and place them into the scene using a pouring gesture above the sand. Also, users have control over properties of the environment, such as water level and illumination via moving virtual objects (see Figure 3, bottom). Moreover, users can place virtual spawn points into the environment. By locating a dedicated virtual object to the sand surface and by performing a "looking up" gesture (moving the head up), users can change to the first person perspective (Figure 4). In this mode, they can directly enter the self-created virtual world and explore it from first-person perspective on a 1:1 scale by relocating and looking around. Looking up again teleports them back into tabletop mode.

Presentation at the Demo Session

Currently the setup allows for single-user in-VR interaction. However, at the same time, multiple users can form the sand and observe their modifications on a display located next to the sandbox setup. Thus, the demonstration will be also interesting and comprehensible for bystanders. One exploration session in VR should take approximately 3 to 5 minutes on average.

CONTRIBUTIONS

With this prototype, we explore the integration of rich haptic interaction with natural materials into virtual reality and present a solution for tracking and presenting real physical materials in VR. In our informal user tests and in a previous expert evaluation we experienced that VR increases the immersive and exploratory aspects of augmented sandboxes, leading to high levels of self-perceived creativity and playfulness.

ACKNOWLEDGMENTS

This project has received funding from the European Unions' Horizon 2020 research and innovation programm under grant agreement No 688244, project first.stage and by the German Federal Ministry of Education and Research in the grant program "Erfahrbares Lernen" (experienceable learning).

REFERENCES

[1] Steffi Beckhaus, Roland Schröder-Kroll, and Martin Berghoff. 2008. Back to the Sandbox: Playful Interaction with Granules Landscapes. In *Proceedings of the 2Nd International Conference on Tangible and Embedded Interaction (TEI '08)*. ACM, New York, NY, USA. https://doi.org/10.1145/1347390.1347421

[2] Tanja Döring, Axel Sylvester, and Albrecht Schmidt. 2013. A Design Space for Ephemeral User Interfaces. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction (TEI '13)*. ACM, Barcelona, Spain. https://doi.org/10/gfsv2b

[3] Thomas Fröhlich, Dmitry Alexandrovsky, Timo Stabbert, Tanja Döring, and Rainer Malaka. 2018. VRBox: A Virtual Reality Augmented Sandbox for Immersive Playfulness, Creativity and Exploration. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play (CHI PLAY '18)*. ACM, Melbourne, VIC, Australia. https://doi.org/10/gfsvjx

[4] Hiroshi Ishii, Carlo Ratti, Ben Piper, Yao Wang, Assaf Biderman, and Eran Ben-Joseph. 2004. Bringing Clay and Sand into Digital Design — Continuous Tangible User Interfaces. *BT Technology Journal* 22, 4 (2004), 287–299. https://doi.org/10.1023/B:BTTJ.0000047607.16164.16

[5] Olga Jarrett, Stacey French-Lee, Nermin Bulunuz, and Mizrap Bulunuz. 2010. Play in the Sandpit. *AMERICAN JOURNAL OF PLAY* (2010), 17.

[6] Markus Persson and Jens Bergensten. 2009. *Minecraft*. Game [PC]. (18 Nov. 2009). Mojang, Stockholm, Sweden. Last played August 2017.

[7] Ben Piper, Carlo Ratti, and Hiroshi Ishii. 2002. Illuminating Clay: A 3-D Tangible Interface for Landscape Analysis. ACM Press, 355. https://doi.org/10.1145/503376.503439

[8] Joan Sol Roo, Renaud Gervais, Jeremy Frey, and Martin Hachet. 2017. Inner Garden: Connecting Inner States to a Mixed Reality Sandbox for Mindfulness. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17)*. ACM, New York, NY, USA, 1459–1470. https://doi.org/10.1145/3025453.3025743

[9] Sergio Álvarez Sánchez, Laura Delgado Martín, Miguel Ángel Gimeno-González, Teresa Martín-Garcia, Fernando Almaraz-Menéndez, and Camilo Ruiz. 2016. Augmented Reality Sandbox: A Platform for Educative Experiences. In *Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality*. ACM, 599–602.

[10] Timo Stabbert, Thomas Fröhlich, Dmitry Alexandrovsky, and Rainer Malaka. 2017. Extending Augmented Sandboxes with Virtual Reality Interaction. In *Mensch & Computer 2017 - Workshopband*. Gesellschaft für Informatik e.V. https://doi.org/10.18420/muc2017-ws08-0339