Fraunhofer HHI

VReha

Intentional, accurate and natural object placement in virtual reality based neuropsychological assessment

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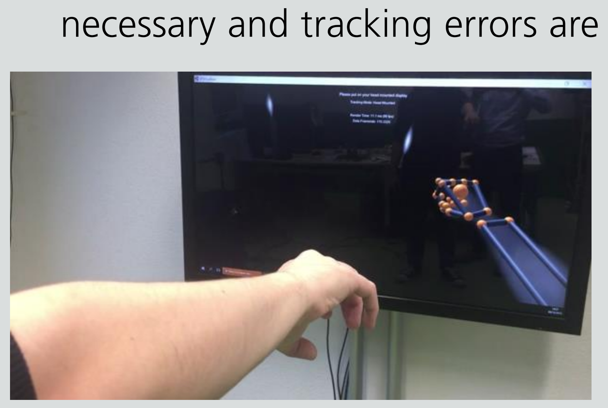
(1) Introduction

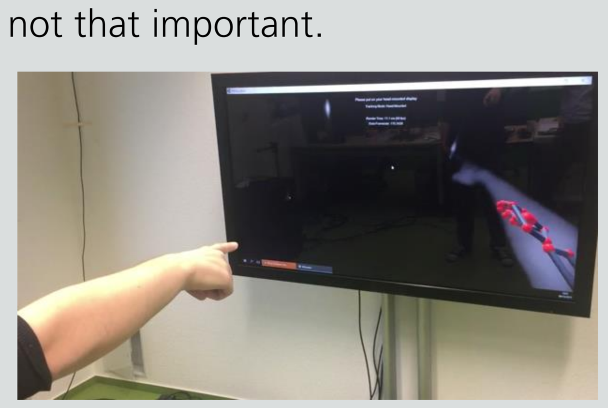
- Relevance of immersive VR in neuropsychological clinical settings is increasing.
- Realistic, high quality presentation of VR environments requires natural and realistic object interactions in VR.
- Training and diagnostic tasks simulated in VR usually require a realistic representation of the real-world mechanics, providing high ecological validity and transferability of the results to the real world.
- Use of game controllers is only an intermediate step on the way to non-intrusive input devices for natural and immersive interactions.
- The aim is a contact-free detection of hand movements and gestural commands, without worn devices.
- This enables an easy to use interaction without additional cognitive load wasted on the recall of the controller's configurations.

(2) Current Situation

- For contact-free interaction in VR the Microsoft Kinect® and the Leap Motion® (LM) are commonly used.

- Kinect is often used from a third-person outside-in perspective for full-body tracking, but it doesn't provide any functionality for precise interaction or gesture detection.
- LM is typically mounted on the VR headset, providing an inside-out mode for short distances, which is currently the state-of-the-art solution for touch-less VR interaction.
- LM is designed mostly for video-game interactions, where a highly accurate, controllable and repeatable object interaction is not necessary and tracking errors are not that important.



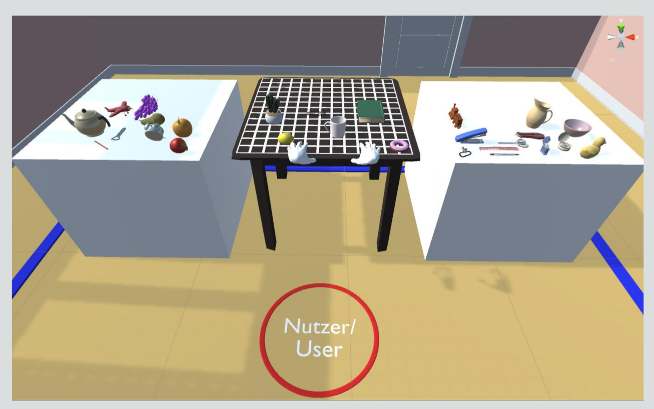


- LM programming interface has predefined interaction logics and physics, that mostly fail to meet the requirements in professional applications.

In the field of neuropsychological VR applications interaction errors frustrate the user and falsify the participant's performance outcomes.

(3) Our Approaches

- Virtual Rehabilitation (**VReha**) project is a joint R&D undertaking, the main purpose of which is to use VR for the cognitive and physical rehabilitation via different immersive tasks designed to evaluate and train the spatial memory and executive functions.

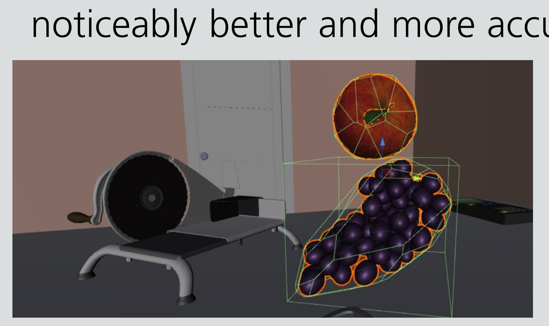


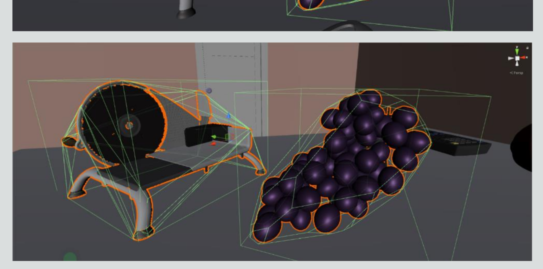
- For the **VReha** project we have developed various adaptations and extensions to overcome the shortcomings of the current standard LM implementations.
- In our immersive Virtual Memory Task (imVMT) users should be able to grab, carry and release virtual objects of different sizes efficiently and accurately.
- Participants should also be able to perform the task quickly and effectively (i.e. errors, such as accidental object drops, should not result in other objects being moved or in time-consuming picking-up of objects from the ground).

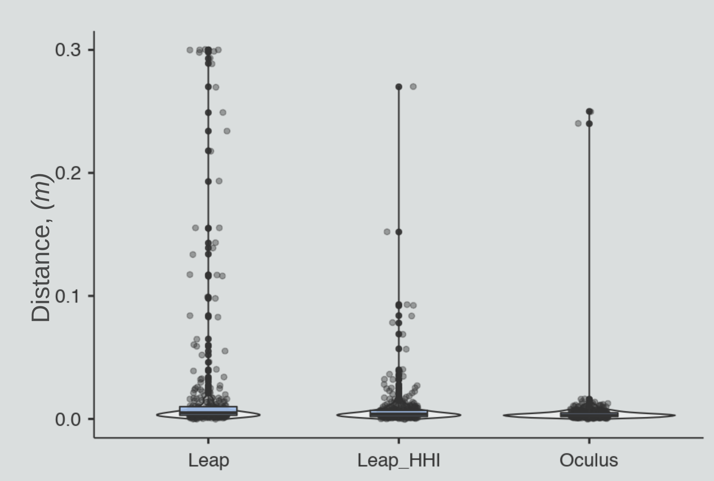
(3.1) VR objects design and physics

- State-of-the-art implementations of contact-free release commands, such as provided by LM, cause errors if the hand is not opened, with all fingers fully extended at the same time.
- Belatedly extended fingers can accidentally give objects a little jolt during the release procedure leading to unintended object movement after the supposed release.
- Another problem with object grabbing is to recognize when the virtual hand is touching the virtual object.

We have optimized the object bounding boxes for grabbing and object physics and introduced several modifications to the standard LM grabbing and releasing approach. Preliminary tests show that this provides a noticeably better and more accurate object interaction.

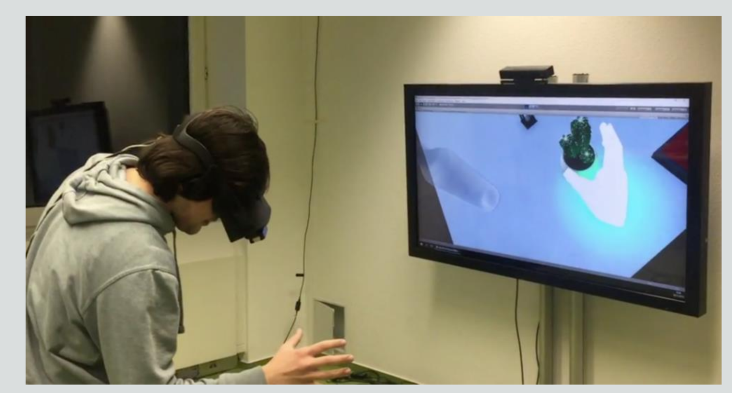


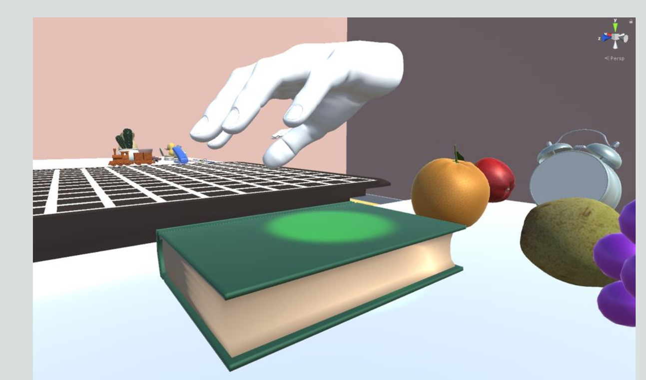


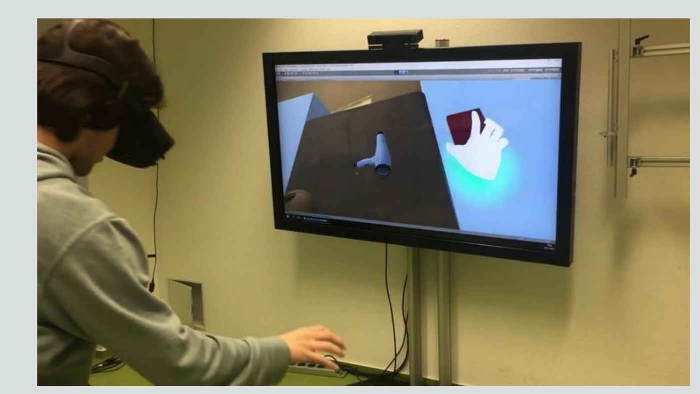


(3.2) Design of interaction logics and feedbacks

- We have introduced a smart object colouring to indicate when an object is in the grabbing distance
- We set the hand representation to be semi-transparent, when grabbing or holding an object, thus the user is able to see even small grabbed objects
- We solved the error-prone grabbing of small objects by joining the object to the user's hand as soon as the hand is in grabbing distance and a grabbing intent is detected
- We introduced audio feedback when grabbing an object and when an object touches the table surface

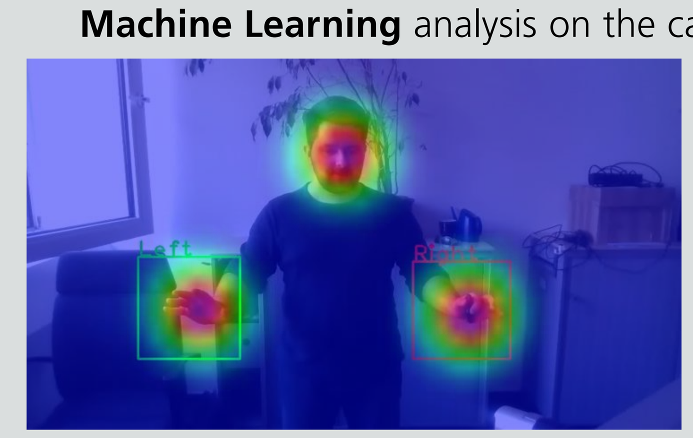


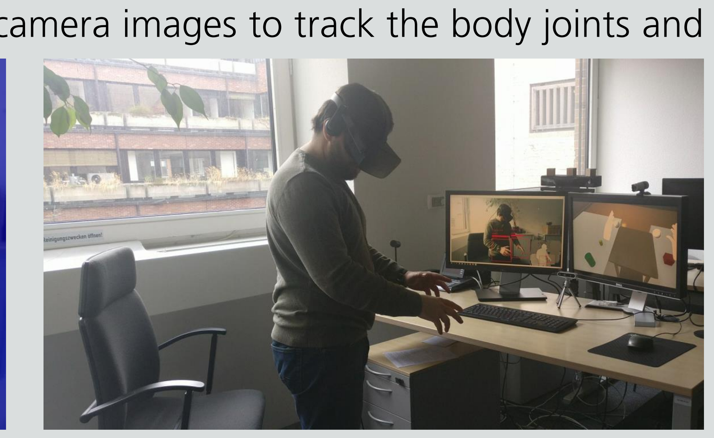


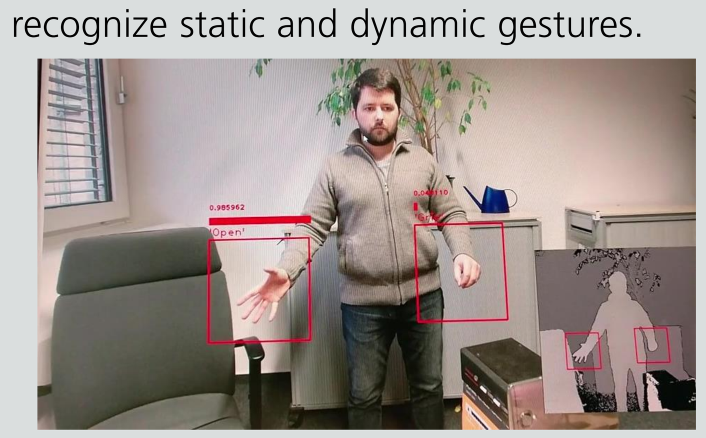


(3.3) Hand tracking using artificial intelligence (AI)

- One of the main problems of Leap Motion is its limited field of view and working distance, and uncertainty caused by occlusions.
- We use an RGB-D sensor (Microsoft Kinect® or Intel® RealSense™) from a third-person outside-in perspective, to be able to see the user's body and cover up for the limitations of the Leap Motion.
- Neither Kinect nor RealSense has any interaction or gesture recognition in their API, so we make up for this using **Machine Learning** analysis on the camera images to track the body joints and recognize static and dynamic gestures.

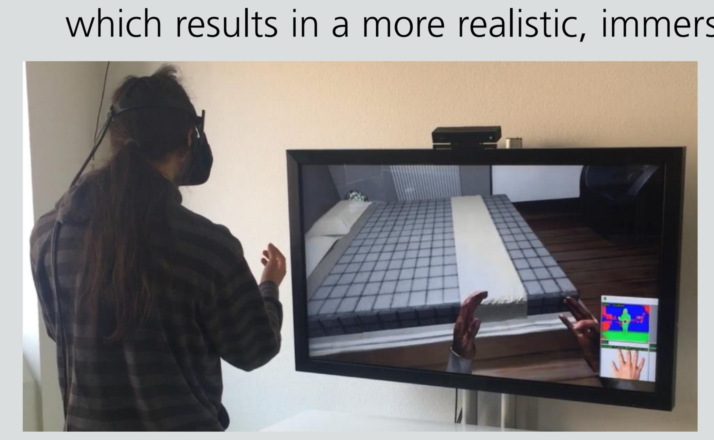






(3.4) Self-representation by multimodal acquisition

- Using this outside-in tracking also allows us to implement full-body representation of the user in the VR environment, which results in a more realistic, immersive and comfortable VR experience.



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