

Interaction in Immersive Virtual Reality

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Overview of interaction technologies

Introduction

Grasping and pinching play fundamental roles for interaction in immersive virtual reality (VR). Indeed, in most of the application, the goal is to ensure that the interaction with the virtual objects resemble the real one, otherwise the training process would be useless.

Main Objectives

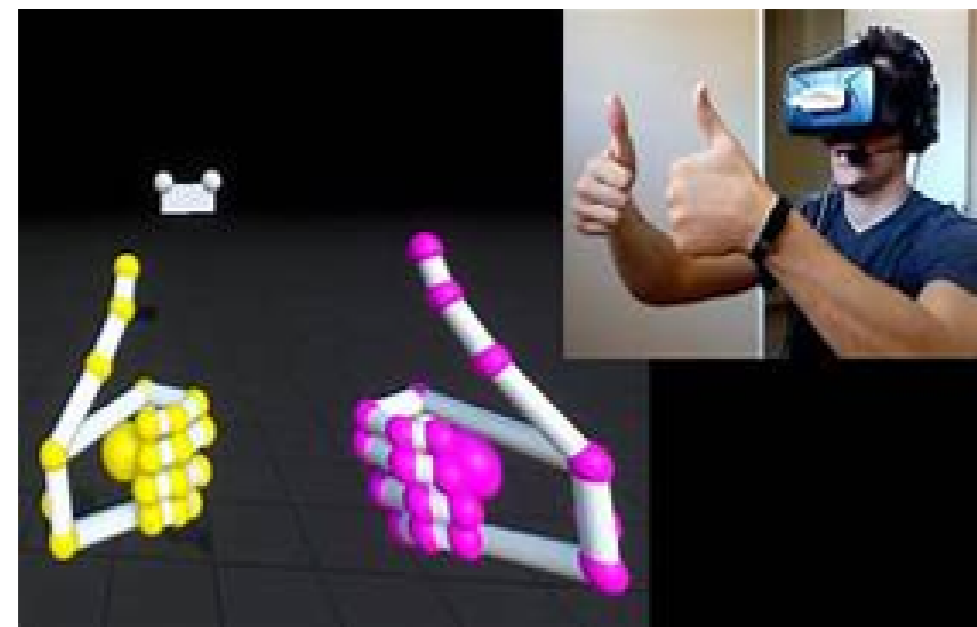
1. Achieve a natural interaction.
2. Analyze different type of feedback.
3. Fingers-object interpenetration in VR.

Materials and Methods

We developed two setups with the same task using the Leap Motion and the Manus Prime haptic gloves.

Leap Motion

- + Non-wearable hand tracking device
- + Good accuracy
- Limited field of view
- Stability and occlusion problem

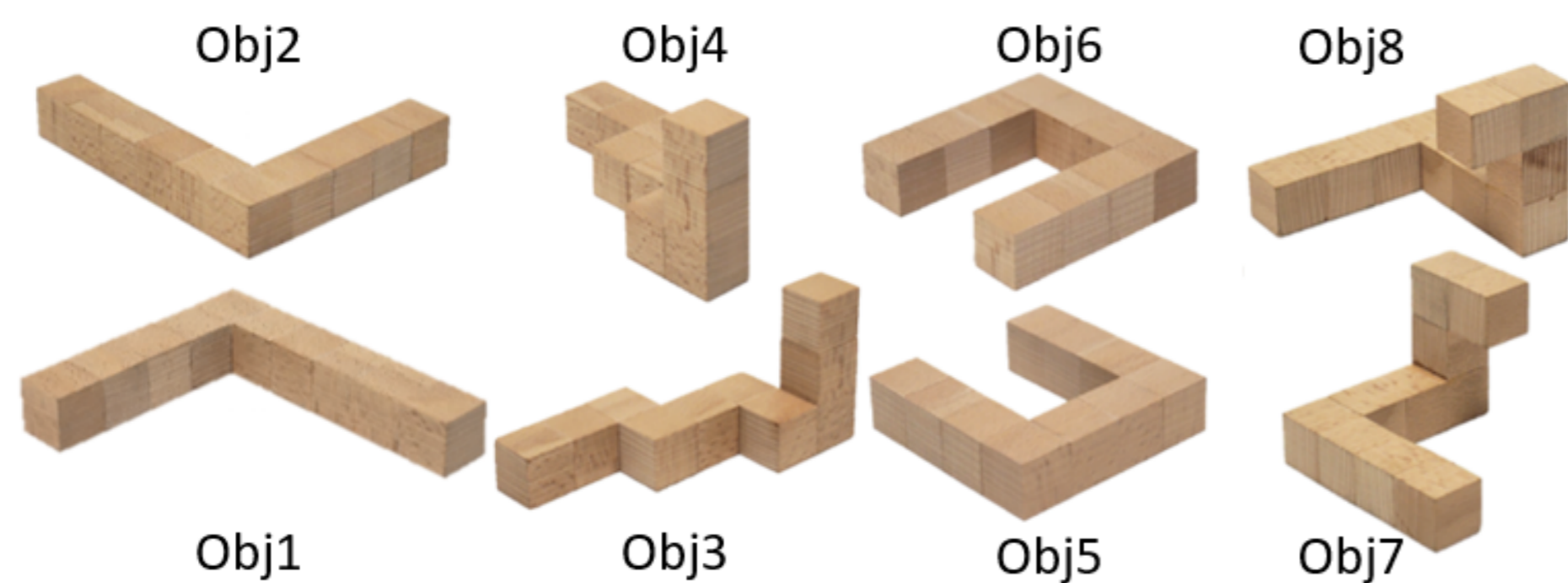


Manus Prime haptic gloves

- + Haptic feedback
- + High quality hands and fingers tracking
- High cost

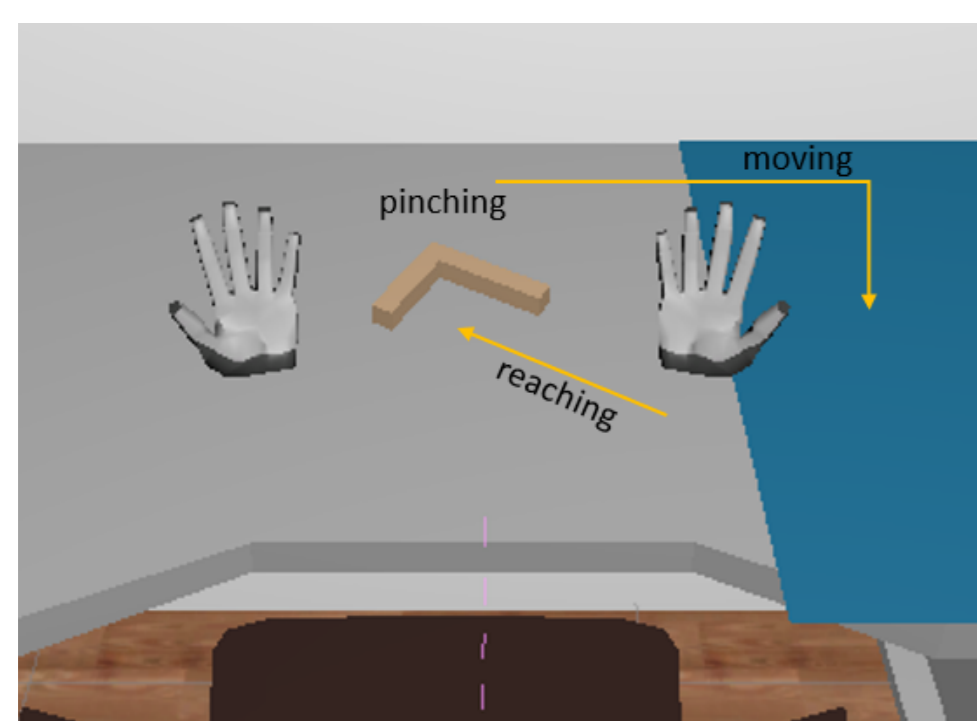


The task consist on reaching, pinching and moving to the blue zone of the desk 4 objects with 2 orientations (8 objects in total).



The condition of the two setups are the following:

1. Feedback analysis providing Audio, visual and haptic feedback one at the time.
2. Studies how the real hand behaves with respect to the virtual ones to analyze the fingers-object interpenetration problem.



Mathematical Section

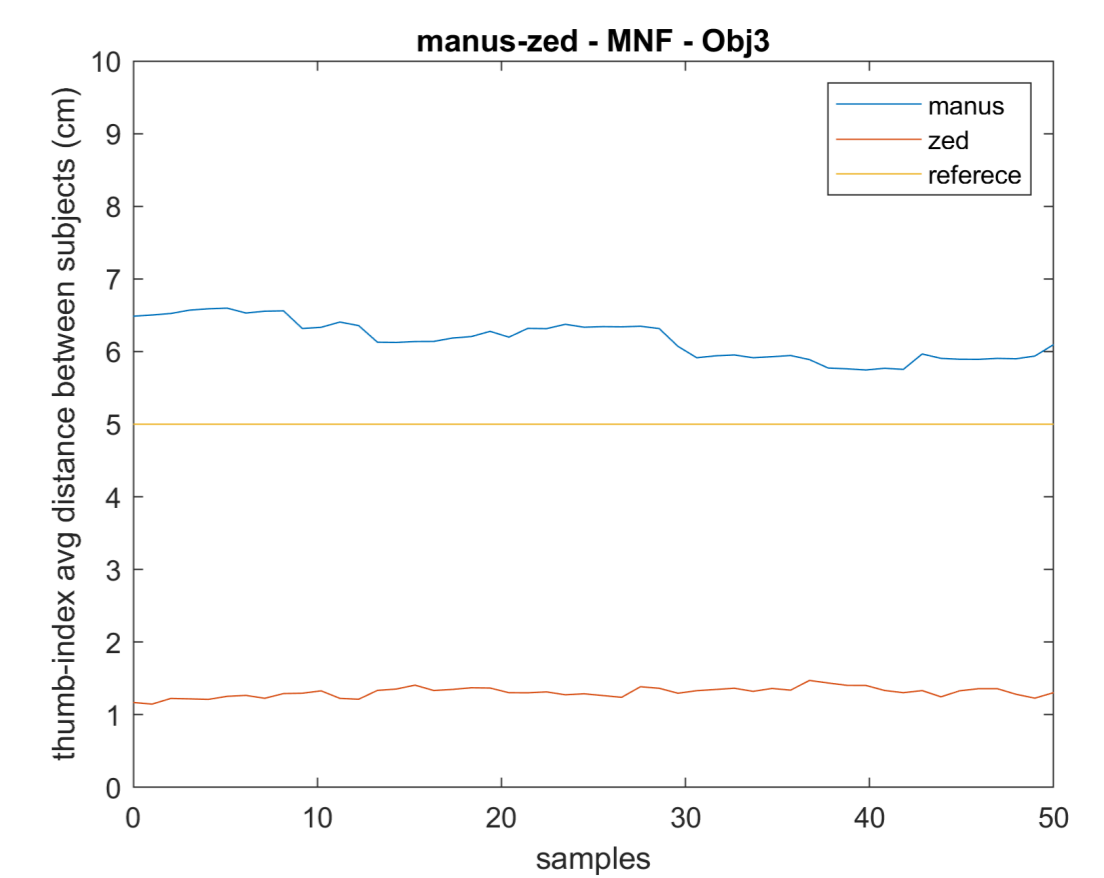
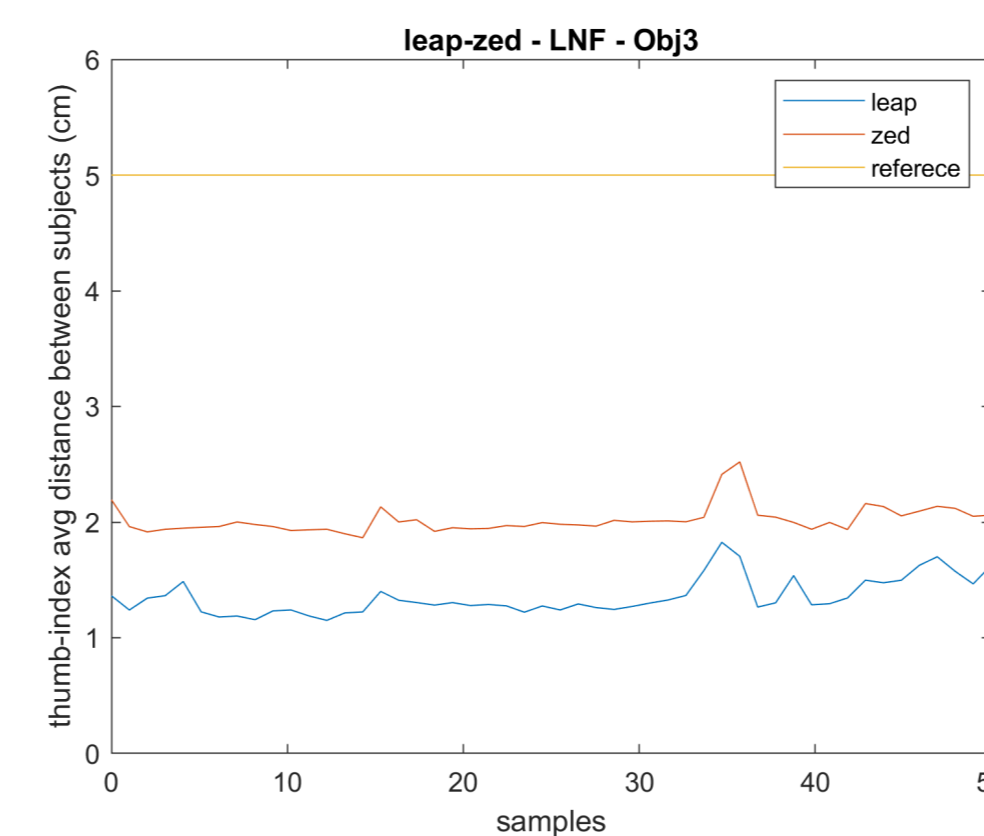
For each condition of the two setups, I acquire two 6D vectors that represent the 3D coordinates of the fingertips during the grasp in the virtual and real environment respectively.

$$G = [T_x, T_y, T_z, I_x, I_y, I_z] \quad (1)$$

where $[T_x, T_y, T_z]$ and $[I_x, I_y, I_z]$ are the 3D coordinates of the tip of the thumb and of the index, respectively. From Eq. 1, we can define the amplitude of the grasp, as the distance between the thumb and the index, when interacting with the object:

$$D = \sqrt{(T_x - I_x)^2 + (T_y - I_y)^2 + (T_z - I_z)^2} \quad (2)$$

Computing this value for both 6D vectors, allow us to study how and if the hand-object interpenetration is affected by the different feedback, configurations and devices.

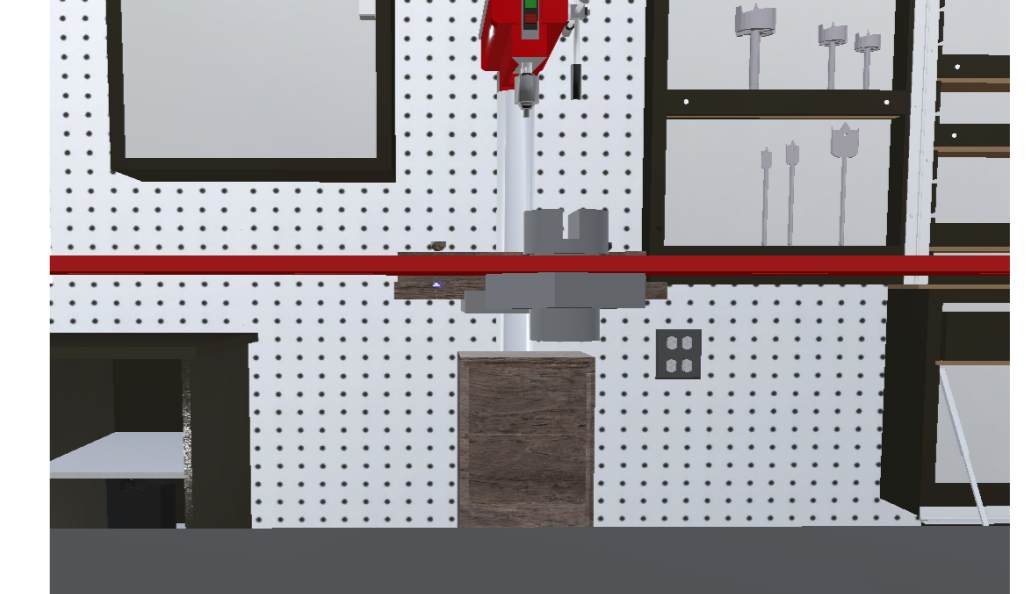
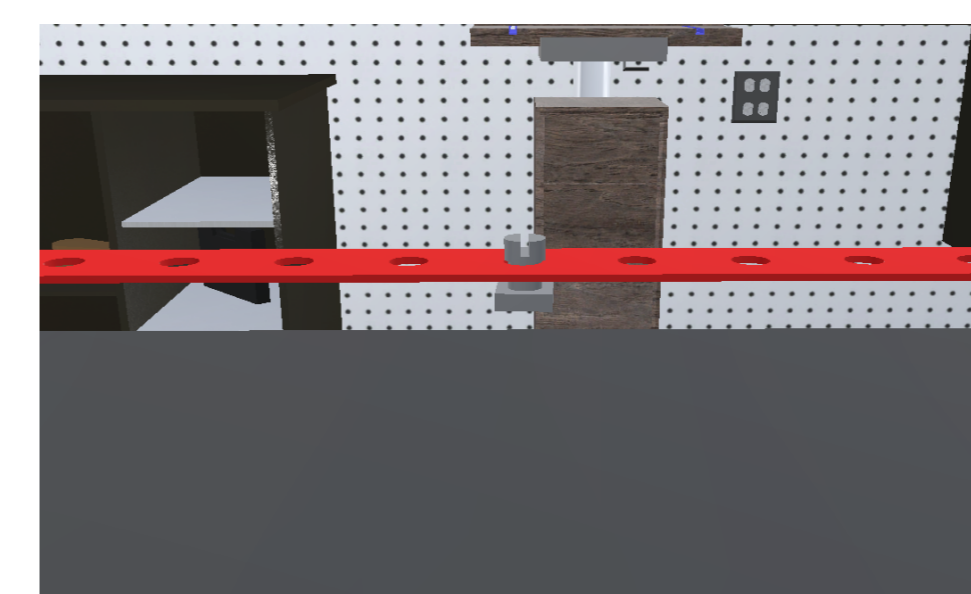
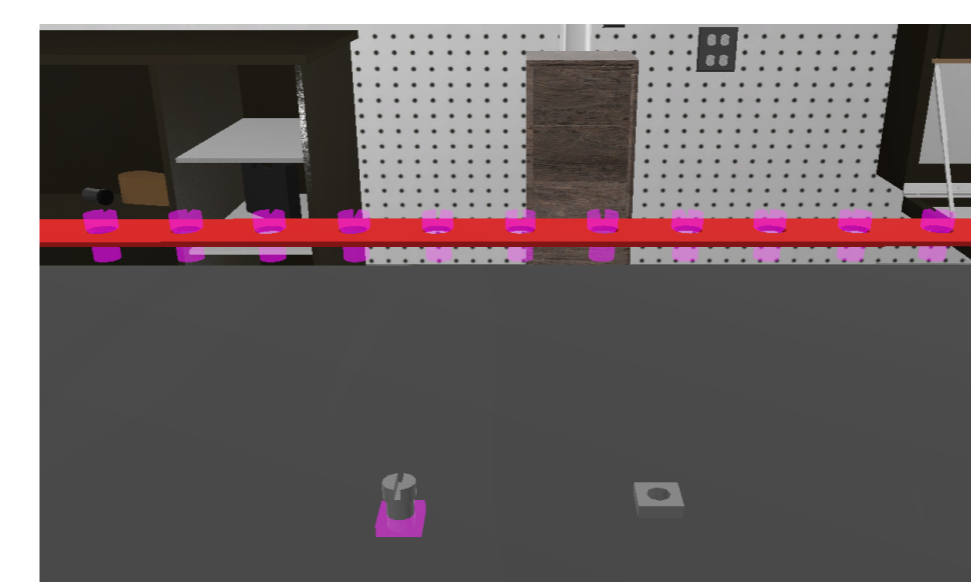


Conclusions

- None of the previous conditions show the real fingers at the correct positions on the object.
- Natural interaction with virtual objects is hard to replicate in VR.
- The task was to simple and fast to further data analysis.

Forthcoming Research

Future research will be focused on fine interaction in which the user has to screw a nut to secure the bolt to a locked strip using natural interaction instead of a gesture based approach.



References

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- [2] Manuela Chessa, Guido Maiello, Lina K Klein, Vivian C Paulun, and Fabio Solari. Grasping objects in immersive virtual reality. In *2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR)*, pages 1749–1754. IEEE, 2019.
- [3] Lina K Klein, Guido Maiello, Vivian C Paulun, and Roland W Fleming. Predicting precision grip grasp locations on three-dimensional objects. *PLoS computational biology*, 16(8):e1008081, 2020.

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