Shifting & Warping

A Case for the Combined Use of Dynamic Passive Haptics and Haptic Retargeting in VR

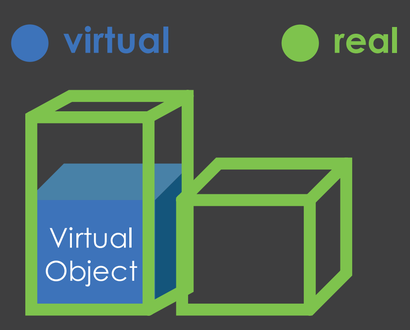
Abstract

Passive haptic feedback for virtual reality (VR) leverages physical props to provide haptic feedback and can achieve immersive sensations but suffers from scalability issues. To tackle these, two independent concepts have been proposed by previous research:

(1) Dynamic Passive Haptic Feedback (DPHF) [1]: A hardware-based concept leveraging actuated props that change their physical state and passive haptic sensation, and
(2) Haptic Retargeting (HR) [2]: A software-based concept redirecting the user's hand during interaction, leveraging manipulations of the real-to-virtual mapping.

While past research on both techniques reported promising results, up to now, these concepts remained isolated. **This paper advocates the combined use of Dynamic Passive Haptic Feedback and Haptic Retargeting for rendering enhanced ranges of haptic effects.**

Prop-Based Haptics for VR:



2 Central Challenges: similarity & colocation

We introduce two thought experiments showcasing that the combination of **Dynamic Passive Haptic Feedback** and **Haptic Retargeting** is beneficial to solve the challenges of haptic **similarity** and **colocation**.

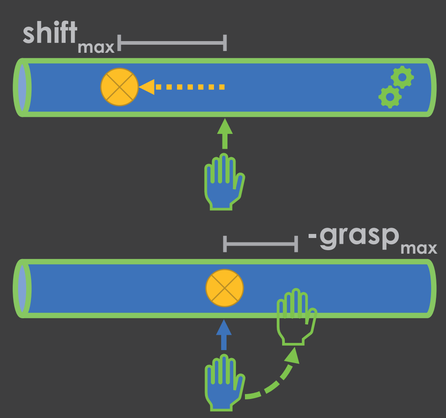
1st Thought Experiment: Haptic Similarity

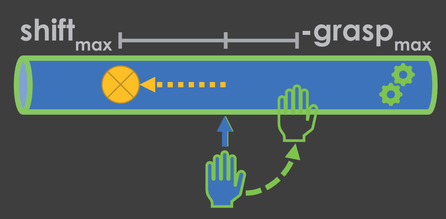
Scenario: A user lifts up a virtual rod represented by a colocated rod-shaped proxy. The VR system renders a weight shift.

Sketched below: The max. achievable shift effects of **DPHF**, **Haptic Retargeting**, and their **combination.**

DPHF
weight-shifting proxy (e.g. *Shifty* [1])
max. lever = $|\mathbf{shift}_{max}|$

Haptic Retargeting
hand redirection (e.g. Cheng et al. [3])
max. lever = $|\mathbf{grasp}_{max}|$





DPHF + Haptic Retargeting
weight-shifting proxy + hand redirection
max. lever = $|\mathbf{shift}_{max}| + |\mathbf{grasp}_{max}|$

Take-Away: Combining **DPHF + Haptic Retargeting** yields increased effect ranges.

virtual real Center of Mass

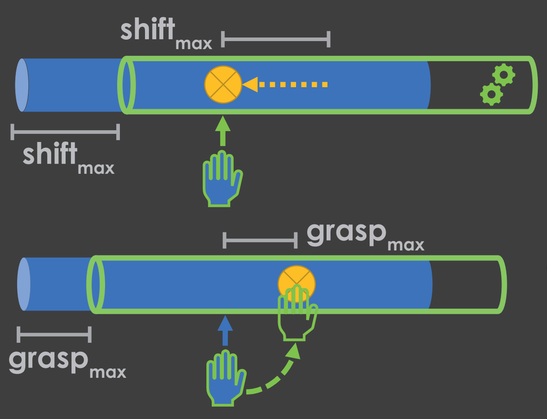
2nd Thought Experiment: Colocation

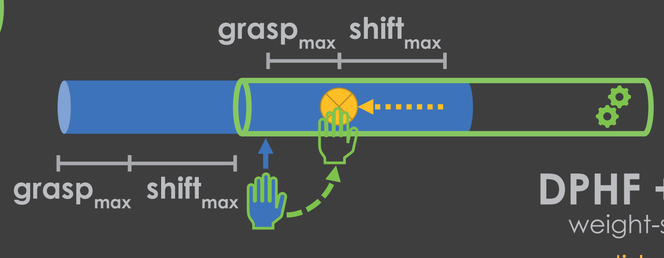
Scenario: A user lifts up a virtual rod represented by a dislocated rod-shaped proxy. The VR system compensates for the dislocation by preventing noticeable weight shift.

Sketched below: The max. unnoticeable dislocation of **DPHF**, **Haptic Retargeting**, and their **combination.**

DPHF
weight-shifting proxy (e.g. *Shifty* [1])
max. dislocation = $|\mathbf{shift}_{max}|$

Haptic Retargeting
hand redirection (e.g. Cheng et al. [3])
max. dislocation = $|\mathbf{grasp}_{max}|$





DPHF + Haptic Retargeting
weight-shifting proxy + hand redirection
max. dislocation = $|\mathbf{shift}_{max}| + |\mathbf{grasp}_{max}|$

Take-Away: Combining **DPHF + Haptic Retargeting** allows for greater dislocation to go unnoticed.

Conclusion

Our thought experiments show that **DPHF + HR** can in certain scenarios provide more flexibility and design freedom by allowing props to represent more virtual objects, and compensating for larger dislocations, than **DPHF** and **HR** individually can. Future work will gather practical insights in corresponding user experiments.

References

[1] Zenner and Krüger. 2017. Shifty: A Weight-Shifting Dynamic Passive Haptic Proxy to Enhance Object Perception in Virtual Reality. *IEEE Transactions on Visualization and Computer Graphics* 23, 4 (2017), 1285–1294.

[2] Azmandian et al. 2016. Haptic Retargeting: Dynamic Repurposing of Passive Haptics for Enhanced Virtual Reality Experiences. In *Proc. CHI*. ACM, New York, NY, USA, 1968–1979.

[3] Cheng et al. 2017. Sparse Haptic Proxy: Touch Feedback in Virtual Environments Using a General Passive Prop. In *Proc. CHI*. ACM, New York, NY, USA, 3718–3728.

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This research was funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – project number 425868555.