Powen Yao
University of Southern California

Powen Yao's Research Statement

My research area is user interface (UI) research and user experience (UX) research in Extended Reality (XR), with a focus on game experiences and environments.

My main interest is in novel interactions that can only be made possible with Extended Reality and Spatial User Interaction. My other interests include Game Design and Artificial Intelligence.

Research Overview

Introduction
In Ivan Sutherland's article from 1965, "The Ultimate Display"[1], he stated, "There is no reason why the objects displayed by a computer have to follow the ordinary rules of physical reality with which we are familiar."

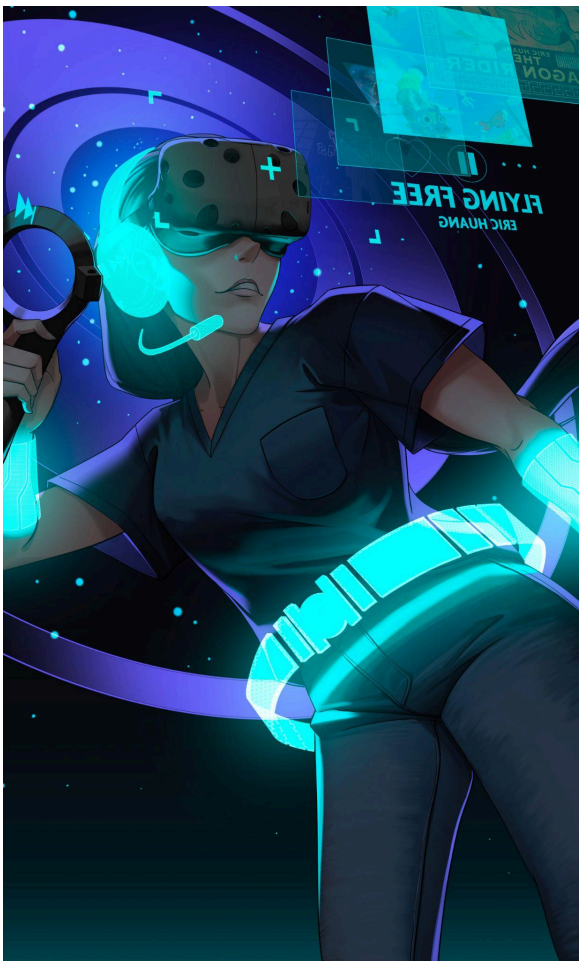
It is on this sentiment that I built my work. I further argue that there is no reason why our interactions with objects and the effects displayed by the computer have to follow the ordinary rules of physical reality with which we are familiar.

Hyperphysical User Interface and Whole Body Interaction
My Ph.D. thesis centers around using two key quality traits, Hyperphysical User Interface and Whole Body Interaction, as lenses for design in UI/UX for XR.

Hyperphysical User Interfaces are defined as "user interfaces that follow laws of physics different from that of our physical world."

Given that anything is possible with Hyperphysical User Interfaces, Whole Body Interaction is used to ground us to what is practical. At the end of the day,

outside of Brain Control Interfaces and the like, the user is still the focus and we must take into consideration what the user can do.



Virtual Equipment System

To explore and understand the use of these two key quality traits, I have built a series of demos, with colleagues and students, centered around the concept of a Virtual Equipment System (VES)[2].

Below is a snippet of VES and how VES challenges our existing concept of Equipment.

VES for Incoming Data (Sensory Settings)[3][4]

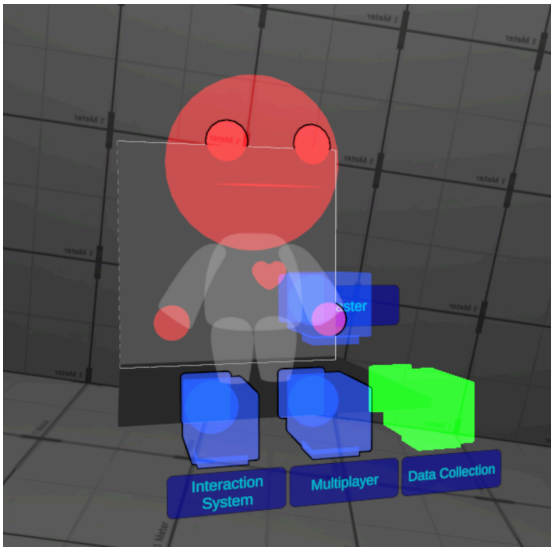
https://youtu.be/xxcpDdt3TkY

VES can take advantage of the user's proprioception and provide equipment associated with different senses through the different parts of the body. E.G., Interaction with Virtual Headphones can change the audio settings.

VES for Outgoing Data (Privacy Options)[5]

https://youtu.be/RazSyF9W1nU

VES can also be used in the same way but for managing privacy options instead. The user can put on a mask to go into incognito mode. Additionally, the user can also manage their privacy options by interacting with a voodoo doll representing the user and with cameras representing observers.



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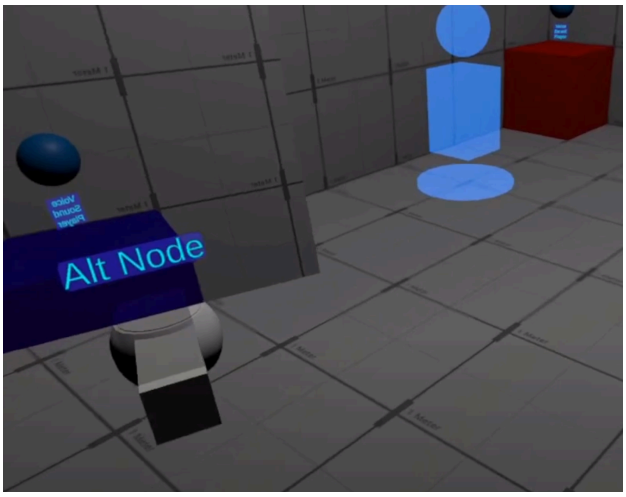
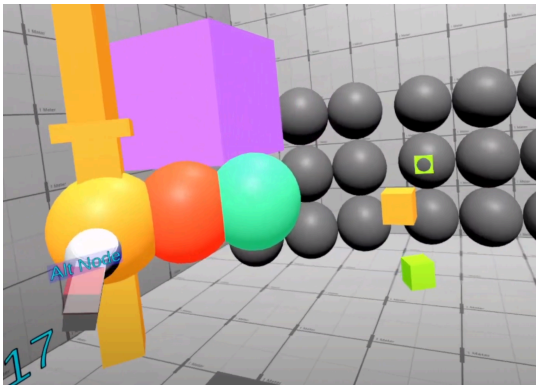
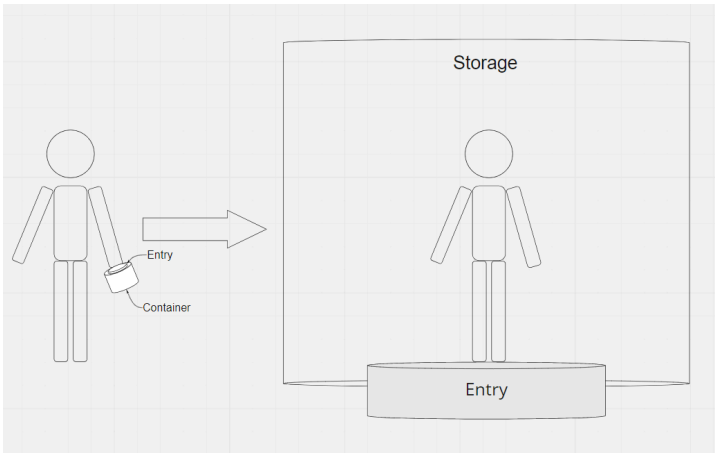


VES for Agent Management (Avatar Settings)
https://youtu.be/D-LNa6N3rd8
VES can also be used to create additional avatars as well as manipulate multiple avatars so that the user can be simultaneously in multiple locations. Avatars can be based on just audio, visual, or the full capacity of the user.

Peripersonal Equipment[4][6]
https://youtu.be/sxZ52EbNGOk
https://youtu.be/v_JQhw6h6wY
With Hyperphysicality, Virtual Equipment can reside in not just personal space, but also in peripersonal space or even extrapersonal space, allowing developers to make use of additional space around the body.





Dimensionality and Extradimensional Storage[7]
Equipment can be filtered, organized, and accessed using the concept of different dimensions. Users can enter inventory systems as physical locations to use spatial sense and spatial memory.

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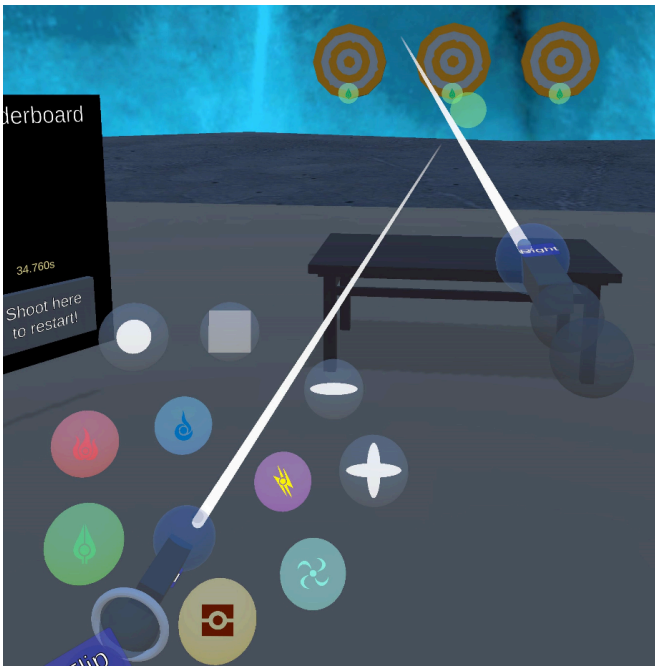

VES Interaction with different classes of gestures.

Users can interact with Virtual Equipment by using motion gestures, surface gestures, and a myriad of other techniques in addition to just moving it spatially as an everyday item. This has led to 1) an ongoing taxonomy paper on gestures in Extended Reality that aims to provide a first step to a unifying taxonomy of gestures and 2) An exploration of spatial interaction in a sandbox with a fantasy backdrop that we call School of Spatial Sorcery.

Research Agenda

I will continue to explore interaction techniques based on Hyperphysical User Interface and Whole Body Interaction. Specifically, it involves:

- Work with experts from other disciplines, such as specialists in other areas of HCI and neuroscientists, to expand, strengthen, and evaluate VES and its related frameworks.
- Evangelize and collaborate on VES to turn it into a general solution that developers can utilize in their work, ideally at the Operating System or game engine level.
- Solidify the design process behind VES into a robust and complete framework that others can use to create their own blend of hyperphysical UI.

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CITATION

[1] Sutherland, Ivan E. "The ultimate display." Proceedings of the IFIP Congress. Vol. 2. No. 506-508. 1965.

[2] Yao, Powen, Tian Zhu, and Michael Zyda. "Designing virtual equipment systems for VR." HCI International 2020-Posters: 22nd International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part II 22. Springer International Publishing, 2020.

[3] Yao, Powen, et al. "Interfacing with sensory options using a virtual equipment system." Proceedings of the 2020 ACM Symposium on Spatial User Interaction. 2020.

[4] Yao, Powen, Shitong Shen, and Michael Zyda. "Virtual Equipment System: First Evaluation of Egocentric Virtual Equipment for Sensory Settings." Virtual, Augmented and Mixed Reality: Design and Development: 14th International Conference, VAMR 2022, Held as Part of the 24th HCI International Conference, HCII 2022, Virtual Event, June 26–July 1, 2022, Proceedings, Part I. Cham: Springer International Publishing, 2022.

[5] Yao, Powen, Vangelis Lympouridis, and Michael Zyda. "Virtual equipment system: face mask and voodoo doll for user privacy and self-expression options in virtual reality." 2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW). IEEE, 2021.

[6] Miller, Mark, et al. "Virtual equipment system: toward peripersonal equipment slots with machine learning." Proceedings of the 2021 ACM Symposium on Spatial User Interaction. 2021.

[7] Yao, Powen, Zhankai Ye, and Michael Zyda. "Virtual Equipment System: Toward Bag of Holding and Other Extradimensional Storage in Extended Reality." Virtual, Augmented and Mixed Reality: Design and Development: 14th International Conference, VAMR 2022, Held as Part of the 24th HCI International Conference, HCII 2022, Virtual Event, June 26–July 1, 2022, Proceedings, Part I. Cham: Springer International Publishing, 2022.