

RESEARCH STATEMENT

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What if one day, your bedroom could reconfigure itself into a living room, an office, a kitchen, a meeting space, a workshop, etc. to support all you need to do within one space? What if you could interact with your surrounding environment as if a partner, a friend, or even an extension of yourself? (see [animation “A Room Alive” \[1\]](#)) These ideas may sometimes sound like fantasies, however, current computer and robotic technologies could easily bring at least part of them into reality. Furthermore, these ideas have great potential and important applications in our lives (e.g., Figure 1 shows a reconfigurable autonomous vehicle interior with robot surfaces). *The frontiers of HCI and HRI are extending to the spatial.*



Figure 1. Reconfigurable Autonomous Vehicle Interiors with Robot Surfaces

My Research Expertise in One Sentence

My research combines HCI, HRI, Robotics, Interaction Design, and Architecture Design to explore how computer-embedded robotic environment could support our activities, extend our abilities, satisfy our needs (both physically and psychologically), and empower our lives.

Key Words for My Research

Human-Computer Interaction + Design; Human-Centered Robotics; Tangible/Physical Computing; Cyber-Physical-Human Systems; Research through Design (RTD); Ethnography & Usability; UX Design; Digital Design Thinking/Visualization/Fabrication; Artificial Intelligence; Interaction Modalities.

Key Research Projects, Publications, and Applications

Project Name (Publications)	Applications	Project Description
Space Agent ([2, 3, 4, 5])	<i>Individual and collaborative work, creative activity.</i>	An interactive & reconfigurable compact office facilitating people at work.
Library Cube ([6, 7])	<i>Learning, library, play, and community</i>	An interactive & reconfigurable learning space for communities in libraries.
Home+ ([8, 9])	<i>Healthcare and wellbeing</i>	Robotic furnishings assisting senior citizens to age at home.
Snowflake	<i>Art and museum</i>	Interactive art installations creating explorative museum experience.

Key Research Pursuits and Activities

I have been investigating the following research topics with the corresponding research activities:

I. Developing Novel Environmental Robotics – A User-centered Approach

I propose the environmental robotics design based on pilot studies, prototype the design for user evaluations, and iterate the design informed by user feedback. Here, I present three examples of my works which are *“Environmental Robotics” (interactive, partially intelligent, and meticulously designed artifacts integrated as part of the environment)*:

1) Continuum Robot Surfaces for Compact Offices and Library Spaces

My PhD dissertation “Space Agent” focuses on robot surfaces and its applications. By embedding continuum robot mechanisms into the architectural surfaces (e.g., ceilings, partitions, walls, etc.) of a compact office, the working space could be reconfigured physically to support various activities at work (e.g., Figure 1). I have been designing, prototyping, and evaluating (UX & usability) continuum robot surfaces featuring remote actuation of tendons embedded within the surface structure [5, 7]. They could also be applied to library spaces cultivating innovative learning environment for communities [6].

2) Robotic Table and Lamp for Senior Citizens Aging at Home

As the research assistant for the NSF funded project “Home+,” I design and prototype robotic table [8] and lamp [9] using digital fabrication techniques. I also conduct user studies with senior citizens [8, 9]. These robotic furnishings help senior citizens to perform essential daily tasks so that they could age at home.

3) Robotic Curtains for “Explorative Environment” Exhibition

“Snowflake” is an award-winning built project for “Explorative Environment” exhibitions at Cornell University. We constructed multiple layers of robotic curtains embedded with proximity sensors to create interactive and explorative museum spaces [10]. As the leader of an interdisciplinary research, design, and construction team, I coordinated the whole project and honed my skills in multiple disciplines including electronic engineering, computer science, digital fabrication, fabric manipulation, user studies, etc.

II. Investigating Human - “Environmental Robotics” Interaction

Interactions between human users and environmental robotics should be carefully investigated and designed, as they are vital to usability and UX of robotic environments. For PhD dissertation, I have been investigating how different user groups would like to interact with the continuum robot surfaces in a compact office for different tasks at work. Together with my teammates, I conducted both qualitative and quantitative user studies to investigate six different interaction modalities instilled with different levels of autonomy (from push-button to fully- autonomous control). The results are presented in the recently submitted paper for CHI 2020, which is also the writing sample submitted for my job application.

III. Proposing Theoretical Framework for Robotic Environment Design

Interactions between human users and environmental robotics will shape our perceptions of the environment and change our relationships to the environment. Based on the “Media Equation,” I proposed that computer-embedded robotic environment could be perceived by human users as a social actor (e.g., a partner, friend, etc.) whose relationship (e.g., partnership, friendship, etc.) with human users could be the foundation guiding the design of robotic environment and its interactions with users [9, 10]. I proposed the concept of “Space Agent” [10] and presented “a pattern-based, design framework for designing collaborative environments” [9] at TEI 2019 conference.

Research Objective

Underlying all my research pursuits is my continued dedication to understanding human needs and wants. I strive to realize cyber-physical artifacts and environments cultivating interactions across people and their surroundings that define places of social, cultural, and psychological significance. I’m particularly interested in helping socially vulnerable populations such as the poor, minorities, children, the elderly, the disabled, etc. by making their living and working environments more supportive, inclusive, and friendly.

Future Research Agenda

Based on my research objective, expertise, experiences, and trainings I received, I will continue my research pursuit in the following four directions:

- Develop novel environmental robotics to empower our lives and help people in need, especially the socially vulnerable populations (e.g., children; senior citizens; people suffering from disease, mental and physical difficulties, etc.) (*potentially with collaboration from faculty members in the fields of Mechanical/Electronic Engineering and Robotics*).
- Investigate interactions between human users and environmental robotics, especially AI embedded environmental robotics with different autonomy levels (*potentially with collaboration from faculty members in the fields of Artificial Intelligence and Machine Learning*).
- Explore the robotic environment (embedded with multiple environmental robotics) and its relationship with human users shaped by different interaction modalities, AI autonomy levels, and user groups (*potentially with collaboration from faculty members in the fields of Psychology and Human Behaviors*).
- Propose design frameworks and theories for different categories of robotic environments based on empirical studies with different user groups and communication theories.

References:

- [1] Yixiao Wang. Animation: A Room Alive (Ph.D. Dissertation: Space Agent). Retrieved September 13, 2019 from <https://yw6971.wixsite.com/mysite/space-agent-phd-dissertation>
- [2] **Yixiao Wang** and Keith Evan Green. 2019. A Pattern-Based, Design Framework for Designing Collaborative Environments. In *Proceedings of the Thirteenth International Conference on Tangible, Embedded, and Embodied Interaction - TEI 19(2019)*, pp. 595-604. DOI:<http://dx.doi.org/10.1145/3294109.3295652>
- [3] **Yixiao Wang**. 2019. Design Interactions between Robot Surfaces and Human Designers. In *Proceedings of the 13th International Conference on Tangible, Embedded, and Embodied Interaction – TEI GSC 19(2019)*. DOI:<http://dx.doi.org/10.1145/3294109.3302962>
- [4] **Yixiao Wang**, Keith Evan Green, Rod Grupen, Johnell Brooks, and Ian D. Walker. 2018. Designing Intelligent Spaces as if They Were Human: A “Space Agent” Framework. In *Proceedings of IEEE 4th International Conference on Universal Village (UV)(2018)*, pp. 1-6. DOI:<http://dx.doi.org/10.1109/uv.2018.8642135>
- [5] Richa Sirohi, **Yixiao Wang**, Samantha Hollenberg, Isuru S. Godage, Ian D. Walker, and Keith Evan Green. Design and Characterization of a Novel, Continuum-Robot Surface for the Human Environment. In *Proceedings of 2019 IEEE 15th International Conference on Automation Science and Engineering – CASE 19(2019)*. DOI:<http://dx.doi.org/10.1109/COASE.2019.8842988>
- [6] **Yixiao Wang**, Keith E. Green, and Ian D. Walker. 2016. CoPRA: a Design Exemplar for Habitable, Cyber-physical Environment. In *Proceedings of 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA 16(2016)*. DOI:<http://dx.doi.org/10.1145/2851581.2892333>
- [7] **Yixiao Wang**, Chase Frazelle, Richa Sirohi, and Liheng Li. Design and Characterization of a Novel Robotic Surface for Application to Compressed Physical Environments. In *Proceedings of 2019 IEEE International Conferences on Robotics and Automation – ICRA 19(2019)*. DOI:<http://dx.doi.org/10.1109/ICRA.2019.8794043>
- [8] Aguiar Carlos Henrique De, Reza Fateminasab, Chase G. Frazelle, Ryan Scott, **Yixiao Wang**, Michael B. Wooten, Keith E. Green, and Ian D. Walker. 2016. The networked, robotic home furniture suite: A distributed, assistive technology facilitating aging in place. In *Proceedings of 2016 IEEE International Conference on Automation Science and Engineering – CASE 16(2016)*. DOI:<http://dx.doi.org/10.1109/coase.2016.7743522>
- [9] Verma Siddharth, Phanideep Gonthina, Zachary Hawks, Dixit Nahar, Johnell O. Brooks, Ian D. Walker, **Yixiao Wang**, Carlos De Aguiar, and Keith E. Green. 2018. Design and Evaluation of Two Robotic Furnishings Partnering with Each Other and Their Users to Enable Independent Living. In *Proceedings of the 12th EAI International Conference on Pervasive Computing Technologies for Healthcare - PervasiveHealth 18(2018)*. DOI:<http://dx.doi.org/10.1145/3240925.3240978>
- [10] Yixiao Wang. Video: Snowflake (Explorative Environment Exhibition). Retrieved September 13, 2019 from <https://www.yixiaowang2019.com/snow-flake-an-interactive-exhibitio>