Animated Surfaces for Novel Robot-Rooms

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Abstract. We discuss novel human-centered intelligent spaces, specifically robotic elements which form the core of an interactive room that physically reconfigures: a robot-room. The proposed robot-room represents an advance in human-centered computing whereby human interaction is within a machine that physically envelops us. We discuss the motivation for such robot-rooms, and present initial work aimed at their physical realization.

Keywords: Robot-Rooms, Robotic, Surfaces.

1 Introduction and Motivation

In 1890, American poet Emily Dickinson wrote, “I dwell in Possibility.” The imagination of this visionary poet transformed her little bedroom wherein she worked into a universe of possibilities – an interior room, continuous and transactional with herself and the outside world, like a Möbius strip. Since Dickinson, other literary figures, artists, architects, scientists, and engineers have envisioned rooms that physically transform (see our diagrams, Fig. 1), both for practical needs (a bedroom becomes an office) or escapist needs (a bedroom becomes a jungle, as in the famous children’s book by M. Sendak). While writers and artists have provided the blueprints, in words and images, for this re-configurable room, architects and engineers have developed some building blocks but not yet a compelling room as a whole.

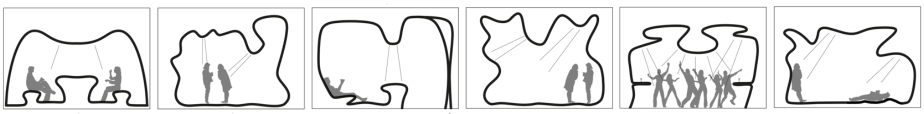

Fig. 1. In concept, a room that physically transforms into other places, for practical ends (dining/office) or “elsewhere**.”**.

1.1 Motivating Use Cases for a Robot-Room

The home, however manifested—house, apartment, co-op, co-housing—is the building typology that accommodates the widest range of human activity. While the home persists as the place for rest, meal preparation, sleeping and socializing, increasingly, home is office and school, playground and gym. On this planet, as we mass-urbanize, as land in certain regions becomes more prohibitively scarce and expensive, and as we spend more time doing more things at home, our homes, getting smaller, necessitate more physical affordances tuned to our busy lifestyles, on the go, at home.

Complicating the strain on the over-programmed home are two associated trends: mass-urbanization and the shrinking size of urban dwellings. By 2050, two-thirds of the Earth's population is expected to reside in urban areas [3]. Meanwhile, the most populated cities are experiencing unprecedented population growth. To accommodate the growing number of urban dwellers, homes are getting smaller: in New York City, dwellings now average 414 sq. ft. per person, in Paris, 388 sq. ft., and in Hong Kong (where home prices have tripled in a decade) 160 sq. ft. and, for subdivided apartments, a mere 48 sq. ft. [3].

We envision the main room of a small home as a robot-room that can actively reconfigure itself to make many places – practical and escapist. We pose two, core research questions: (1) how can a home be outfitted with a robot-room that re-configures into "many places", practical and escapist – serving effectively as an "everywhere home"? and (2) how are inhabitants of a robot-room supported and augmented by it, following real-world needs?

1.2 Use-Cases for Robot-Rooms

To identify real-world needs for a robot-room, we turn to how people are living today, as documented in two articles from The New York Times:

1.2.1 Use Case 1: A Robot-Room Serving Practical Needs

"They Remodeled Before Covid. Here's What They Regret Now," January 14, 2022 [1].

Pre-pandemic, the architects for a loft remodel in New York City allocated one-third of the loft's space to work activity, two-thirds for family life. This allocation worked well at the start of the pandemic "when the grandchildren often visited, using the open living space as a playroom"; but soon, "desperate for more space and quiet, … the 4-by-7-foot closet in the guest room" became an office entered by ducking under a beam. In this closet-office, "there were days when Mr. Uriu was on the phone trying to salvage his business …, while Ms. O'Mara was trying to keep the attention of children as she taught art classes over Zoom, separated [from Mr. Uriu] only by Soji screens."

This provides motivation for a robot-room, adaptive to changing programs, serving practical needs.

1.2.2 Use Case 2: A Robot-Room Serving "Escapist" Needs

"How to Escape Without Leaving Your Home," October 13, 2020 [2].

The concept here is sensible: "If you think about escaping as a way to give your mind some time to reset, rather than seeking out a new physical space, you can find respite without going outside." The author then offers "seven strategies for creating an oasis at home"; however, all but one of these strategies requires "set[ting] up and tak[ing] down ad hoc," like a "side-street café."

This provides motivation for a robot-room, a portal to "other places," serving escapist needs.

These two, real-world scenarios selected from The New York Times currently serve as our two use cases for testing robot-room prototypes.

2 Realization of Robot-Rooms

Robot-rooms are a new category of robots, distinct for not existing within a space, but rather a space-making body that offers researchers a unique set of technical challenges and that represents a new kind of human-machine interaction whereby people are enveloped by the robot. We expect to learn from the proposed research more about how people – dwellers in tight confines – live in robots. As we increasingly expect robots to become a part of our everyday lives, then developing a robot-room represents a transformative advance in human-centered robotics.

2.1 Vision and Physical Prototypes

A vision statement for our research endeavor was presented in [4]. In that paper, we defined a robot-room as an…… articulated, programmable, physical environment embedded with integrated digital technologies. […] The novel aspect of [a robot-room] is its ability to continuously "morph" to accommodate a wide range of user need by way of its smooth, continuously deformable…surfaces.

We envisioned these surfaces being, for example, "a storage wall that bends to become a ceiling that finally becomes four moving arms holding computer screens, and a morphing work surface." In the same paper, we categorized three behaviors of a robot surface: bending, twisting, and shape shifting We define two concepts for a robot-room, drawn again from our earlier "vision" paper [4]: "Concept-1," defined as "a typical room with…an insertion of a series of shape-shifting, ribbon-like components"; and "Concept-2," defined as "a seamless, three dimensional envelope rather than the collection of components." In Fig. 2, we illustrate these two concepts in diagrammatic terms: the *Components-in-a-room* concept ("A"); and the *Whole-room* concept ("B"), made of three modules: a plane (d), a corner (e) and an angle (f) that together, in multiples, create a seamless room envelope. Fig. 6 also offers visualizations (from our earlier work) of the two concepts: "C" being suggestive of the *Components* concept; and "D" being suggestive of the *Whole-room* concept. We are currently constructing and testing the modules in "A" and "B".

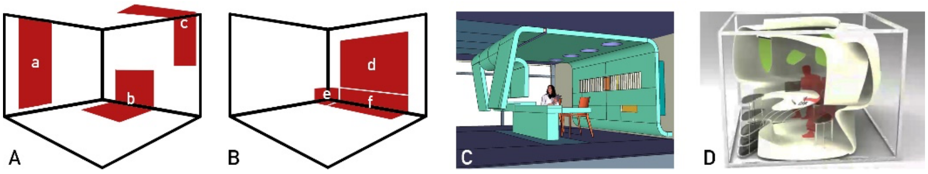

Fig. 2. Two robot-room concepts and semblances of what they might look like: (A) the *Components-in-a-room concept* where (a), (b) and (c) represent three robot-surface components; (B) the *Whole-room concept*, made of three modules: a plane (d), a corner (e) and an angle (f) that together, in numbers, make a room envelope; (C) and (D) are visualizations we made some years ago that, respectively, are suggestive of the *Components* and *Whole-room concepts*.

2.2. User Experience (UX) Study

We plan to conduct a User Experience (UX) study with participants to develop a deep understanding of what characterizes a robot-room, informed by human needs and wants. Characterization of the robot-room will contribute a foundational understanding of space-making robots for the research community to build on. The UX study will investigate the experiences of participants interacting with prototypes representing the two robot-room concepts. This UX study will be conducted in-person using full-scale, rapid prototyping as accomplished successfully in previous research by our team (as reported, e.g., in [5]) with preliminary results in as little as one week.

The goals for the User Experience Study are: (a) identify strengths and weaknesses of each of the two robot-room concepts; (b) determine users' satisfaction with alternative manifestations of each of the two robot-room concepts; and (c) characterize experience to clarify what is a robot-room, communicated as design guidelines.

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