Figure 1: Giorgio de Chirico. *Furniture in the Valley* (1928) [21]. "A great intimacy is born between them."

Figure 2: *home+* furnishings (prototype-2): *h+cube* (left) and *h+lamp* (right). A great intimacy is also born between these two. (The design of this system is very much ongoing.)

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Strange Places: Loci of Design Inspiration

Abstract

The inspiration for designing tangible, embedded, and embodied interaction can come from stranger places than needs assessments and observations. In conceptualizing *home+*, a pair of interactive furnishings enabling independent living, our design-research team found inspiration in modern painting and contemporary dance. Giorgio de Chirico's painting "Furniture in the Valley" (1928) captures the curious vitality and intermingling of furniture outside their normal confines that our team translated into this active pair of *home+* robots and their intimate rapport. Two contemporary dance works, Andrea Miller's "(C)arbon" and Ohad Naharin's "STOP," explore the interrelationships of three bodies, coping with their circumstances, which inspired the interoperability and control strategies across the pair of robots and a human "in-the-loop." This paper aims to inspire other design researchers to seek, in strange places, inspirations for tangible, embedded, and embodied interaction.

Author Keywords

Design Methods; Enabling Technology; Interaction Design; Dance; Surrealism; Robotics; HRI.

CSS Concepts

- Human-centered computing~Interaction paradigms

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Figure 3: Early sketch of *home+* furnishings: *h+lamp* (left) and *h+cube* (right).

Figure 4: *h+cube* (prototype-1): exterior—panel removed. The red-colored body measures 46.65 cm (18.37 in) along any length, and is encased in composite panels having a polyethylene core faced in aluminum. Each of *h+cube*'s four legs is a linear actuator having a stroke length of 15.24 cm (6 in). We fabricated multiple components using a 3D printer and a CNC router working from our digital shop drawings.

Introduction

Needs assessments, observations, interviews, usability studies, and other methods of participatory design have long served designers in the process of designing interactive artifacts that are elegant, desirable, and empathetic (following partly the classical principles of good design—*firmitas*, *utilitas*, and *venustatis* [27]). But all too often, these same methods become the under-examined means for validating design processes that fall flat. For designers (broadly defined), there is, as Harrison, Back, and Tatar offer [12], the unfortunate tendency of “dressing up design methods as more systematic and predictive than they are.” Overwrought manifestations of such design activities include, in Kolko’s critique [16], “two-hour ‘subject matter expert’ interviews,” “‘canvasses,’” “‘playbacks,’” “‘design sprints,’” and “lots and lots of Post-it notes.” While this tendency can be attributed to those designers who blindly follow the script of “design thinking” [16], it also is attributed to those “potential users”—the participants in design studies—“who don’t necessarily do or want things that make” [26] compelling interaction design.

Recourses to this tendency comes in different forms, including: a deeper, more immersive engagement with user populations [16]; grounding design in phenomenology [13] (e.g. embodied interaction [9]); and the use of mixed methodologies drawn from across disciplines as curated by this designer [1, 12]. Partly in sympathy with the last form of recourse, this paper offers an alternative response that obliges designers to travel to strange places in search of strange things. A case study for this paper—our team’s design of a pair of interactive furnishings named *home+* enabling independent living (as defined in [14, 24, 31])—

elaborates our response (adventure?) and serves as a means for its validation.

Stopover-1: “Strange Things” that Change

Maybe you can remember an instant in your life when some interior environment familiar to you (your bedroom?) or welcoming to you (a vacation retreat?) was momentarily transformed into the unexpected—a place alive to unforeseen prospects. Surely, you can remember an occasion from your childhood when the familiar contents of your bedroom changed their appearance, as they did to the delight of the Italian artist and writer Giorgio de Chirico a century ago.

One such vision, captured in de Chirico’s painting, “Furniture in the Valley” (1928) [23], profoundly influenced our design of a pair of furnishings as enabling technology. De Chirico’s painting (figure 1) shows an upholstered chair, a headboard from a bed, an armoire or a chest, and what might be a fence from a garden—clearly, a physical environment far from home. As de Chirico writes in an essay, describing this enigmatic place:

Perhaps you have occasionally noticed the singular aspect that beds, mirrored armoires, armchairs, divans, or tables have when you see them suddenly in the street, amidst a décor in which we are not accustomed to seeing them, such as happens during a move, or ... before the doors of shopkeepers and second-hand dealers who display the principal pieces of their merchandise on the sidewalk. Then the furniture appears to us in a new light; the pieces are dressed with a strange solitude; a great intimacy is born between them, and one could say that a strange happiness floats in this narrow space that they occupy...[8].

Figure 5: *h+cube* (prototype-1): interior detail.

Figure 6: *h+lamp* (prototype-1): interior view of the lamp's base.

Furnishings that are familiar to our living rooms but encountered in an unfamiliar context have, in de Chirico's imagination, come to life—with “emotion,” and an “intimacy formed between them.” “Furniture in the Valley” is an invitation, as de Chirico offers, “to live in the world as in an immense museum of strange things...that change their appearance” [8].

De Chirico is not alone in an intellectual and artistic landscape of “lively” buildings, rooms, and furnishings; but his painting and words show that there is perhaps more to the familiar places we live in than the static, fixed reality of them. De Chirico opens the doors, so to speak, to the concept of a *living room* of furnishings that have a strange vitality; and we sought this prospect with the aid of computation and robotics.

Designing the hardware of home+ robots

Giorgio de Chirico's “Furniture in the Valley” (1928) captures the curious vitality and intermingling of furniture outside their normal confines that we translated into a pair of robotic furnishings.

Inspired by de Chirico, we envisioned networked, cyber-physical home furnishings, each having different functionalities tuned for different purposes to support a common human need or to exploit an opportunity to improve the lives of co-inhabitant(s). Our conception of *home+* is comprised, on the surface, of commonplace furnishings of an ordinary home – a lamp, a nightstand, an armoire, a wardrobe – that become “animated,” working intimately, together and with their human “cohabitants,” to perform routine, domestic, “CS-PFP 10” tasks [21] defining independent living. *home+* strives to empower people to remain in their homes for as long as possible, even as their physical capabilities alter over time, and, in more grave circumstances, to afford people

some semblance of feeling ‘at home’ as users move between their dwellings outfitted with home+ and assisted-care facilities equipped the same way.

Shaped by that “great intimacy” formed between de Chirico's furnishings, and their capacity “to change their appearance,” we then sought to validate this inspiration from places closer to our home in HCI, HRI, and interaction design. In this light, the transformation from familiar domestic furnishings to those of home+ is achieved, borrowing the words of William Mitchell, by way of “geographically distributed assemblages of diverse, highly, specialized, intercommunicating artifacts” that render the physical environment a “robot for living in” [19]. In similar terms, former *Wired* editor Kevin Kelly imagines a future, artificial “ecology” of intelligent “rooms stuffed with co-evolutionary furniture” and a “mob of tiny smart objects,” all having an “awareness of each other, of themselves, and of me” [15]. In this spirit, we situate home+ opposite a robot servant such as PR2 [29]: the distributed cognition of home+ versus a unified, humanoid intelligence.

In recent years, we have developed a number of home+ prototypes, including a robotic chair [7], a robotic wall partition [7], and robotic tables [7, 24]. Our current and most advanced home+ furnishings are a robotic pair: a mobile, robotic cube and a continuum-robotic lamp that we call *h+cube* and *h+lamp* (figures 2-6, 9-11). *h+cube* and *h+lamp* are designed to work as complements within the volume of the typical room of the home or workplace: *h+cube* specifically engages in tasks within a spatial volume bounded by a room's floor, upwards to approximately hip or table height, while *h+lamp* engages in tasks from hip or table height, upwards to near the ceiling of a typical room.

Practically, h+cube (see figures 4 and 5) is a mobile robot that lifts objects from directly beneath it by way of linear actuators at each of its four legs working in concert with a jamming gripper, located at the core of the cubic volume and extending from a fifth, shorter linear actuator designed to rotate 90 degrees and 180 degrees. This ensemble is capable of transporting the retrieved object to a shelf, to a human co-habitant, or to the terminus of h+lamp. Tugged about the interior living or work space by h+cube and deposited by h+cube where needed, h+lamp (see figures 6 and 9) has a mast comprised of a linear actuator closest to the floor extending continuously to a tendon-actuated, flexible continuum arm that is terminated by a jamming gripper and a bright light as means for illuminating task spaces. The mast ensemble can reach from below the top of the h+cube to the highest shelf in most homes or offices to transport objects across living and workspaces. h+cube can itself transport larger bins filled with objects (e.g. laundry or groceries) atop it. As just mentioned, h+cube and h+lamp work together with their human co-inhabitants to perform ten routine tasks enumerated in the “CS-PFP10” scale used by healthcare providers to define the capacity for independent living, as considered in [10, 14, 28].

Comprised of multiple, commonplace domestic artifacts, home+ manifests something of the behavior of swarms, and also subscribes to the notion of the a-life community that, in living systems, the whole is more than the sum of its parts. The remarkable feature of the home+ project is that, seemingly, the everyday furnishings found at home “come to life,” forming a “living” room. To-date, we have performed user studies

of the *home+* pair with 5 older adults and 12 medical staff as we continue iterating our design of this interactive, enabling system [25].

Stopover-2: Strange Dances

We’ve arrived at two contemporary dance works: Andrea Miller’s “(C)arbon” [18] and Ohad Naharin’s “STOP” [20]. In one of three rooms that serve as the stage for (C)arbon, two dancers—females—strong-willed yet clearly fatigued, are intent on transporting a third dancer—male—who is on the brink of collapse (figure 7). He unsteadily walks across a wall almost entirely by way of the strength remaining in his two partners. In an instance in STOP (figure 8), three dancers again—all female—move with and against each other.

Figure 7: Andrea Miller, (C)arbon [14].

Figure 8: Ohad Naharin. STOP [16].

Designing the interoperability of home+

When we see a humanoid robot, we expect of it behaviors akin to ours. But when we encounter robot furnishings like the home+ pair of robots, we don't really know what to expect from cyber-physical furniture. Where to find inspiration?

"(C)arbon" and "STOP," two contemporary dance works exploring the interrelationships of three bodies coping with their circumstances, inspire the interoperability and control strategies across the pair of home+ robots with a human "in-the-loop." The dancers of these works are not idealized, or dramatizing a tale, or moving gracefully; they are, notably, *striving* or *straining* or *seeking*, or simply aiming to survive. In the strange beauty of the two dance trio's movements can be found insights into "bodies in emotion" that can be translated to interaction patterns in the pair of robots (figures 9, 10, 11, and 12). The motion planning of the robots is strangely beautiful—not quite machine or human.

Figure 9: home+ choreography: bending, reaching.

Figure 10. home+ choreography: reaching, extending.

Figure 11: home+ choreography: crouching and lifting.

A Designer's Ticket to Travel

This paper presents a single case of discovering design inspiration in strange places. It is meant as provocation and plea. The productive value of discovering design inspiration in strange places has elsewhere been investigated [3, 4, 11] and rather robustly in a meta-analytical review of 43 design studies [22] which found that when designers identified a “single and uncommon source of inspiration (like a de Chirico painting), the designers engaged in “a deeper search in a specific and remote domain, facilitating the generation of high-quality and novel ideas.” A similar study [6] concurs with this finding, but with the caveat that “conceptually closer, rather than farther sources appear more beneficial.” Is de Chirico’s furniture or the dance works of Miller and Naharin “too far” from the interactive system they inspired? Should designers resist flying so far? This paper takes the longer view, urging designers to travel far. As Brue Mau urges designers in his much-referenced “Incomplete Manifesto of Growth” [17], “allow events to change you. [...] The prerequisites for growth: the openness to experience events, and the willingness to be changed by them.” Designers of

tangible, embedded, and embodied interaction should freely avail themselves to strange places and find inspirations there.

Tangible Expressions (Supporting Files)

Supporting this paper and its presentation are two “tangible expressions”:

- Video of home+ choreography:
<https://vimeo.com/289141439>
- home+ webpage presenting the work-in-progress:
<https://arl.human.cornell.edu/research%20-%20home+vision.html>

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Figure 12: The strange dance of *home+* and a human co-habitant, working at home.

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