Robots as Furniture, Integrating Human-Computer Interfaces into the Built Environment

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ABSTRACT

What will the universal remote control of the near future look like? What form will the next generation of human-computer interfaces take? Will they be conspicuous interfaces within the built environment, like a computer screen or a smart speaker? Will they resemble the ubiquitous, portable rectangles that we all carry in our pockets? We propose a third paradigm: interfaces that hide in plain sight, inconspicuously integrated into the furniture always already around us, but ready to be called upon when needed in order to establish a user interface. Our furniture-robot prototype - **tbo**, the TableBot - demonstrates the viability of this furniture-based human-computer paradigm.

Figure 1: tbo being used as a table

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; • **Hardware** → *Displays and imagers*; *Sound-based input / output*; *Tactile and hand-based interfaces.*

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KEYWORDS

human-robot interaction; situated robots; household robots; furniture; architecture; human-centered design

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1 INTRODUCTION

Mark Weiser begins his seminal article on ubiquitous computing—"The Computer in the 21st Century"—with the following quote: "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." [5] [4]

But it is only relatively recently that the technology has caught up with the vision and promise for ubiquitous computing articulated by Weiser and his colleagues at XEROX PARC nearly 30 years ago.

As the technology that connects us becomes even more pervasive and integrated into our daily lives, designers must address increasing expectations for ubiquity and portability. The current paradigm, by and large, assumes that each user possess their own private, local device, the smartphone being the most prevalent example.

But what if we thought about these interfaces in a different way? What if we thought of these interfaces as a public good rather than a private object? [1] What if we could shift from a paradigm of personal handheld devices to one where public space is saturated with interfaces that create affordances for ubiquitous computing? What if we could integrate these interfaces directly into the surrounding infrastructure?

The tbo prototype explores the viability of integrating "Situated Robots" into the infrastructure of the built environment, with a specific focus on furniture within both pubic and semi-private spaces. [1]

Situated robots can be defined as robots that are, "embedded in complex, challenging, often dynamically changing environments." [2] But our approach to Situated Robotics goes beyond the development of robots that must simply navigate their environments.

This design paradigm places a particular emphasis on the relationship between spatial affordances and user experience. In this sense, Situated Robots are both situated and situational. They are situated in the sense that must operate within the affordances and constraints of the environment. They must first and foremost operate as furniture, and perform the necessary functions of furniture, both in terms of their relationships to human bodies, and their spatial relationships. These align with concerns that an architect,

for example, might address: questions of spatiality and human scale. But they are also situated within a sociolinguistic context, and must address how these objects convey meaning; how will they be read culturally and socially, and how they will become discoverable to the user.

But these objects can also be said to be "situational," in that these robots afford the user the conditions for adaptive interactions and diverse functionality, i.e. they can adapt to divergent situations. The user first encounters these objects not as robots, computers, or "technology", but as simple, everyday objects, such as a table or shelf. [3] They are inconspicuous because they are quotidian objects. The interface adapts to the needs of the user.

While looking into the concept of situated robots, we decided a platform that could be used in order to observe how people react to a robot-furniture hybrid is necessary to conduct further research into this field.

2 DESIGN OBJECTIVES

The development of tbo gave us the opportunity to examine several features that we believe will be of primary importance to future iterations of these kinds of robot-furniture hybrids. In addition to tbo's role as a piece of furniture, i.e. a table, we designed tbo to experiment with concepts such as situated robotics and mobility, as well as building a platform for HRI research.

Figure 2: tbo's internal and external hardware design

Situated Robotics

Unlike most household robots, tbo is was built around its identity as a round, wooden sofa-side table. When powered off, all its internals are hidden inside its wooden shell and it functions exactly like a table. Using a projector instead of a monitor allows tbo to look like one as well. tbo becomes situational when it gets a video call; it then comes to life in order to fulfill its purpose as an autonomous robot capable of capturing video/audio of its user as well as projecting the video call on a nearby wall.

The decision of eliminating the screen, in favor of projecting images onto walls and other surfaces, allows the robot to be more adaptive to its situated environment by using its surrounding structured environment to create portals to other, non-contiguous spaces.

Mobility

Unlike most furniture, tbo can move through and navigate in its environment; tbo uses SLAM to autonomously identify flat surfaces to project video onto, as well as to navigate through the household. In addition, we implemented an intuitive manual drive interface that uses the rotating tabletop as a handle for pushing tbo around.

Figure 3: tbo being used as a platform for teleconference

Platform for HRI Research

We designed tbo to be able to adopt different functions in order to serve as a platform for HRI research. tbo was designed with many different strata with specific features, with separate strata for computation, projection, SLAM, sound, camera, and voice recognition. The inclusion of such functions allow tbo to constantly evolve as a testing ground for human-robot interaction. For example, we experimented with using the tabletop as a dial; as well as adding voice recognition functionality using the Watson API.

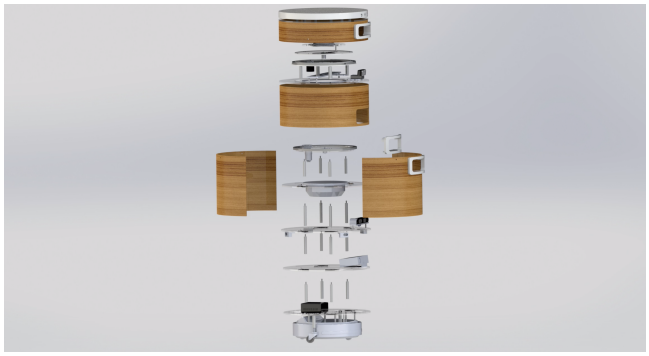

Figure 4: tbo is designed with easily accessible internals and empty "hackable" strata to add features

3 CONCLUSION

We believe robots have the capability to drastically increase quality of life in a regular household situation, but it is important to make sure robots in households are designed in such a way that they fit with their surrounding environments. tbo is a first in a series of "situated robots" that are designed to integrate with the built environment, and we believe it is the direction household robotics need to take.

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