Microsketching: Creating Components of Complex Interactive Products and Systems

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ABSTRACT
One of the problems with empathic research methods in interaction design is that the leap between findings about people and design is often left undocumented. In this paper, we describe a microsketching, a method for producing rapid concept sketches that emphasizes creative exploration of the aesthetic and interactive possibilities of the individual elements of a technology, rather than seeking to develop a complete product. We discuss the use of microsketching within the design process, and provide a case study of its use with an experienced designer and in a design studio course. We discuss how microsketching can be used to scaffold the leap between data collection and design, to quickly introduce designers outside of the research team to the elements of the design problem, and to teach novice interaction designers how to design the interface and interaction for complex products and systems.

Author Keywords
Design, Design Research, Interaction Design, Sketching, Cultural Probes

ACM Classification Keywords
H.1.2 [Information Systems]: User/Machine Systems — Human factors; General Terms: Design, Theory

General Terms
Design

INTRODUCTION
Recently, interaction design researchers have turned more and more to qualitative, ethnographic and arts-inspired research methods to understand the situations surrounding technology use. These methods, traditionally drawn from disciplines such as anthropology and contemporary arts practices [2,5,6], are often reduced and simplified as they are translated to the design community. In extreme cases, these research methods are reduced to one canonical name such as "probes" [2] or "ethnography."

There are several other challenges with using qualitative ethnographic and arts-inspired research methods and the resulting information to design interactive technology systems. First, these methods provide little scaffolding between collection and design, leaving the implicit decisions of the design team undocumented. Second, it is difficult to rapidly and creatively prototype these types of designs. Prototyping is a central activity of design through which design knowledge is both gained and expressed [9,21,22]. The technical overhead makes prototyping cumbersome and rapid prototyping nearly impossible. Finally, the variables and design primitives of these systems are so numerous and complex that it is difficult to comprehend and address them in totality, especially when keeping the needs of users in mind. This is especially true for students and those who are novices in designing interactive systems with both physical and digital components.

In contrast, consider the task of designing an interface for a

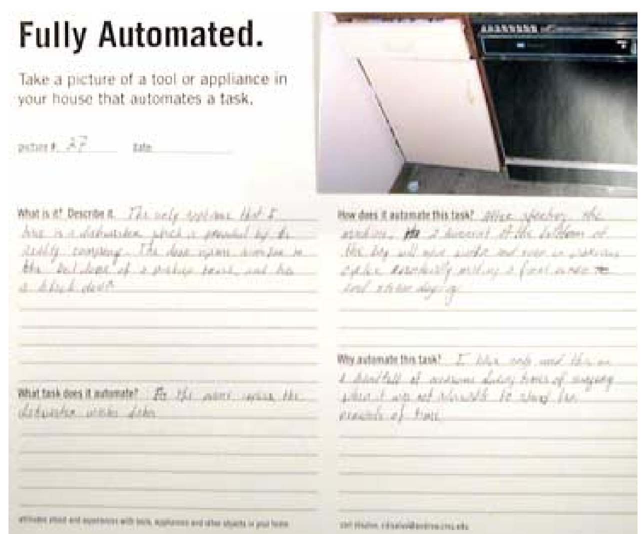


Figure 1. Sample probe filled out by a participant.

web site. Much of what is known about how people will access a site can be easily documented through straightforward interviews or lab studies. The design elements of the interface can be easily identified. Furthermore, the relationships of typography, color, composition, etc. within an interface have been established through exploration, experiment, and reflection [15]. It is simply not as clear where to begin when designing complex interactive systems.

The goal of this paper is to introduce the microsketching method. We have developed this method to bridge the gap between the use of ethnographic and arts-inspired methods such as cultural probes, the design of interactive products and systems (for an example, see Figure 1), and the process of designing. When microsketching, designers focus on a single image or idea from a cultural probe as a means for creative inspiration and idea generation. Microsketching emphasizes the creative exploration of aesthetic and interactive possibilities of individual elements of a technology product, keeping the needs of people in mind, rather than seeking to develop a complete product.

We believe that microsketching allows designers to bridge the gap between "inspirational data" and the discovery and invention of elements that are most suitable for design without being burdened with the responsibility of conceiving of complete products. Furthermore, we believe that microsketching supports interaction design by facilitating the rapid creation of nuanced, inventive, and whimsical designs. This method is not intended to replace other methods that focus on whole systems, but rather, to offer an alternative or auxiliary method for expediting concepting in the early phases of design or in educational settings.

In the next section, we discuss related work on sketching relative to interface design. Next, we introduce the design brief, the method, and the audience for our microsketching case study. Like most design processes, it is replicable, but understandably, each time the method is used, the design outcomes will differ. Next, we discuss outcomes relative to the form, function, and interaction of the resulting concept designs. We conclude with a discussion of the advantages and drawbacks of the microsketching method as presented here, and discuss next steps for this work.

BACKGROUND AND RELATED WORK

The design process, shaped by the Industrial Revolution, has been well characterized (for example, by [12,13,17]). The constituent activities include understanding the current problem or current situation by understanding overlapping factors including social, economic, and technological contexts; exploring how to improve the future through the design of new artifacts, services, systems, or environments; considering not only product function, but also the aesthetic, symbolic, emotional and social qualities of products; and codifying understanding and movement towards a solution in the form of sketches, models, prototypes, and other tangible expressions of ideas. A key aspect of design activity is that in seeking a solution to a design problem, design seeks beneficial change [17].

One of the most significant challenges of involving designers in future-thinking, complex problems is striking a balance between the intuitive, implicit decisions at which designers excel and the explicit decision-making that progresses the design to its final state. Numerous generative, exploratory, and prototyping methods have been researched and developed, but few have been consistently and easily applied to the design of interactive systems. Particularly in educational settings, students need methods to help them move from designing 2-dimensional interfaces to designing the interactions of 3-dimensional products with multi-modal interfaces.

Sketching is often used to formalize this leap. Sketching is quick, timely, inexpensive, and disposable [3]. A primary creative activity, sketching is one of the cornerstones of designing, and comprises the foundation of elementary art, design, and engineering education.

A body of research has explored how interacting with sketches during the design and evaluation process can be useful. Whether designers are working individually or in a team, sketching has been proven to be invaluable during the beginning of the design process, for quickly covering the opportunity space and for rapidly generating a set of rough ideas [11]. Other research has argued that sketches serve a number of purposes in progressing a design, most notably understanding perceptual relationships and non-visual functional relationships within a proposed solution, for example in an architectural sketch [23].

For these reasons, a number of HCI researchers have begun to develop tools to support sketching and ideation during the design, development, and evaluation process, most commonly for interface design. This work generally addresses the observed need for sketching tools that allow designers to quickly generate large numbers of sketches, freed from limiting tools that require time to be spent on creating detailed designs [10, 11]. Other tools have explored how to support numbers of designers working in collaboration, or multidisciplinary teams working towards a unified design [8, 16, 20, 26]. Still others have explored how hand-drawn sketches are preferable to formal diagrams or digital sketches during the design process, and how they elicit more user feedback and spawn greater numbers of revisions [18, 24].

However, other research has noted several issues in linking rapid conceptual ideation by sketching to collections of ambiguous, playful data, such as data collected by cultural probes. Boehner et al noted that "the leap between probe and design is often left undocumented" [2]. Our work focuses on capturing this aspect of exploration through sketching, in the hopes of making this process more accessible to both trained designers and those collaborating in design teams.

Figure 2. Example of a staged photo by a participant. Generated in response to the question "What task would take more than one robot to do?" the photo depicts the multiple tools that are necessary for total housekeeping.

Figure 3. Example of a creative interpretation by a participant. Generated in response to the question "What in your home is most unlike a robot?" the photo is of a favorite chair with a balloon tied to it.

MICROSKETCHES: THINKING IN PARTS, ESCHEWING WHOLES

Microsketching is focused sketching on a few elements of a product, rather than a whole product. Microsketching builds on the creative tradition of design sketching, continuing the tradition of exploring the material, formal, and gestural aspects of new technologies that was begun and formalized in the Bauhaus and epitomized in the work of Moholy-Nagy [14]. The sketches explore and express qualities of a product without requiring the product to be "complete." Since the goal is rapid and focused exploration, a microsketch can take any form: a scrap of paper, a piece of a fabric, a collage, a photograph, or even a short textual description. The only qualifier is that the sketch be rich in description. The essential aspect of a microsketch is to describe what an element of a product might be like.

Microsketches are the inverse of product concepts. They are the specifics of unspecified products. Whereas product concepts attempt to produce a vision of a whole, the intention of a microsketch is to stay focused on the parts. Thinking in parts and eschewing the whole allows for focused investigation of design possibilities. These possibilities can later be brought together into a single product, or appended to an existing product. The activity of integration comes later in the design process, so that it will not greatly detract from the attention paid to the aesthetics and experiential qualities of the elements in the microsketches.

Microsketching relates to the process of designing as cultural probes relates to the process of researching human experience in order to change that experience through design. In the following case study, we deployed cultural probes early in the design process, and expanded their use for design ideation beyond the core design team. Our use of the probes extends and contributes to the development of the probes method by employing them as inspiration source material for use by individuals and teams, trained in the discipline of design or new to designing, to help scaffold the leap between collecting data about people, interpreting the responses, and creating designs for future technology systems.

CONTEXT OF THE STUDY

The microsketching process is described in this section within the following design process. Cultural probes were used to understand the overlapping elements of context within a design problem. Individual pages from the probes diary were used to facilitate the microsketching process. Three types of designers — design researchers responsible for collecting data, a professional designer that had no relationship to the data, and a team of student designers — embarked on the microsketching process. They represented movement towards a final solution through sketching, prototyping, and refinement of initial ideas.

The design brief

Our design brief emerged from our research on the use of robotic technology in the home [19]. After 18 months of data collection, our team of product and interaction designers was poised to embark on developing product concepts, or stories of how appropriately designed technology could improve the current experience [17]. To do so, our team itself needed to engage in rapid, creative ideation, without being overwhelmed by the volumes of data. We also hoped to engage designers who were not on the research team to assist in this process, and to train a set of future interaction design students in doing this type of work. In all cases, the final goal was to produce visionary product concepts which illustrated stories of human change that would communicate how to best design technology to the engineers on our team.

Understanding the current situation: cultural probes

We initially deployed a set of cultural probes. The general topic of the probes was home automation and domestic robots. Research participants were recruited by placing an advertisement in a local paper, and by posting to local email distribution lists. The cultural probe packet consisted of a disposable camera and spiral-bound paper booklet with 18 primary questions. Each primary question had three sub-questions associated with it. For 16 of the questions participants were asked to answer the questions and take a corresponding photograph (Figure 1). For the remaining two questions, participants were asked to sketch their responses. Ten probes were sent out and nine were returned, resulting in approximately 150 entries and 120 images. In all cases, these were captured by female heads of the household, who were largely responsible for housecleaning. Ages of these participants ranged from early 20s to late 60s.

In the tradition of the cultural probes, questions were broad and purposively provocative, in the hopes of providing inspiration for the design team. Rather than asking participants to imagine robots of the future, which would be nearly impossible, we asked participants to reflect on the products and practices in their current domestic environment, and to ponder how those products and practices might be different. In composing the questions, we were interested in possible ideas about future robotic appliances in the home. For example, one set of questions was entitled "Keeping An Eye Out," and reflected an interest in machine vision, asking: 1) What is something in your home that you have to watch? 2) Why do you have to watch it? 3) How do you watch it? 4) Could someone else watch it for you?

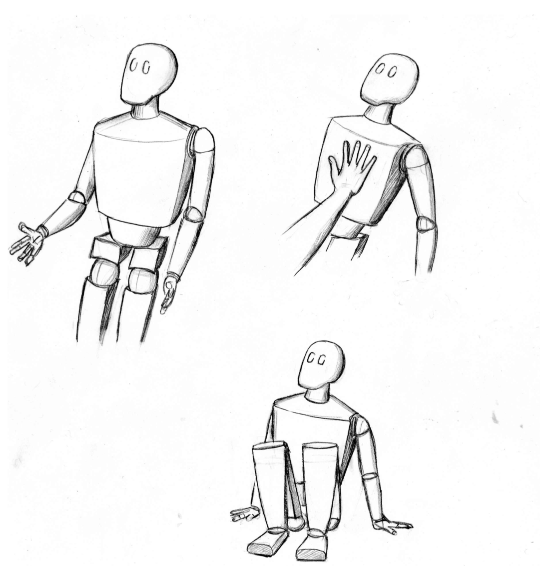


Figure 4. Users can push the robot over, where it will wait until it is summoned for use again.

In taking photos, the participants were encouraged to be creative and not literal. They were asked to use photography as an opportunity to "illustrate" what they had written and to "interpret" the questions visually. The resulting photographs both provided glimpses into a diverse range of homes, which would later serve as contexts for sketching, and showed creative ideas in the form of "staged" photographs, "still-lifes," and "assemblages" that would have never been imagined in the same way by the designers (Figure 2 and 3).

Rather than coding the cultural probe data to move towards a unified idea of what is right, we left the data open for interpretation, to open up a variety of possibilities [2]. Our intention was to emphasize the distinctiveness of each participant and each entry, because this distinctiveness maximizes the detail available to designers and the resulting inventiveness of the sketches. For the microsketching process, data must remain detailed and be made visually available for the design team. The rich, differentiated images and descriptions set the tone and the context for sketching.

Exploring how to improve the future: microsketching

The microsketching technique was used by three types of designers in this project. First, the technique was used by members of the design research team to move from existing research to product concepts. Second, it was used by an experienced designer, not on the research team, to understand the context surrounding the problem and to generate product concepts. Third, it was used by 17 students in a multidisciplinary interaction design studio course, to facilitate learning how to do interface and interaction design for three-dimensional product plus interface designs. In this paper, we focus on the second and third uses, and discuss the advantages and drawbacks of each in the discussion section.

The experienced designer had little knowledge of robotics and no experience working with cultural probes. However, the designer did have extensive drawing and sketching experience. To facilitate microsketching, he was given one page and associated image from a diary at a time, and asked to draw five initial sketches for that page. This was done a total of ten times. The resulting sketches were then grouped thematically, and advanced to more refined concept ideas. The total time for this exercise was 14 weeks: one week for each probe page and four weeks for grouping and refinement. During the refinement phase, the research team served as the client, making suggestions for direction and sketch refinement.

Seventeen students in an advanced interface and interaction design course had backgrounds ranging from music, fine art, design, and architecture to cognitive science, computer science, and even biology. The goal in leading this group through microsketching was to scaffold the leap from rich, ethnographic data to design, and also to lead students easily into creating interface and interaction designs for complex, multimodal systems. The timeframe for microsketching was short — only two weeks from inception to initial refined concept. For the class exercise, each student was given one page from the same participant diary, and given approximately one hour to sketch from the entry. The only rule imposed was that the sketch must be specific to the entry. After each student sketched for an hour, the sketches were presented and critiqued. Students were then clustered into thematic groups of three and required to sketch again, with the rule that the collaborative sketches must include an element of each of the three individual sketches. One week later, students were asked to present a scenario of use for a refined concept that had been developed by the team of three.

THEMES AND SKETCHES

The concepts that emerged from the microsketching activities of the student teams and the experienced designer can be grouped into three broad categories: form, function, and interaction. Overall, these sketches captured the intricacies of the probe data, suggesting whimsical, creative ways to engage robotic technology in the home.

Form

Form refers to the shape, volume, texture and materials of physical aspects of the product or system. From the probes data, designers learned that the scale of the robot plays an important role in how it is interpreted; for the design students in particular, scale of a solution is often taken into consideration much later in the solution process. Additionally, the professional designer learned from the probes data that complex mechanical structures, such as modernistic spot lighting in a living room, might be a desirable aspect of a robotic product. Rather than immediately producing humanoid or animal forms, both groups focused on the adaptation of existing forms in the home, or the construction of complex mechanical forms, guided by what they found in the probe images. Those who did explore humanoid and animal forms did so in novel ways that emphasized the awkwardness of those forms or adapted them to be more user-friendly in unexpected ways.

Scale: Robotic appliances can be small and fragile

Probe data showed that the ability to exert physical control over the robot was of greater concern than what robot actually looked like. One's ability to assert physical authority over the robot was a theme that emerged again and again. Whether the designed form was human, animal, or alien, designers relied on forms that are small and/or fragile to communicate human power over the system. For example, for a humanoid robot concept, the student designer stated:

> "The humanoid is a common form for robots, but even a short, three-foot robot at over 200 lbs would be intimidating in stature and presence. Unless, of course, it could be easily knocked down. The humanoid robot is then designed such that with a simple push on its chest or back, the robot collapses to the ground where it stays until it is called to rise again. Despite the intimidating stature and presence of the robot, it easily succumbs to the slightest of physical bullying." (Figure 4).

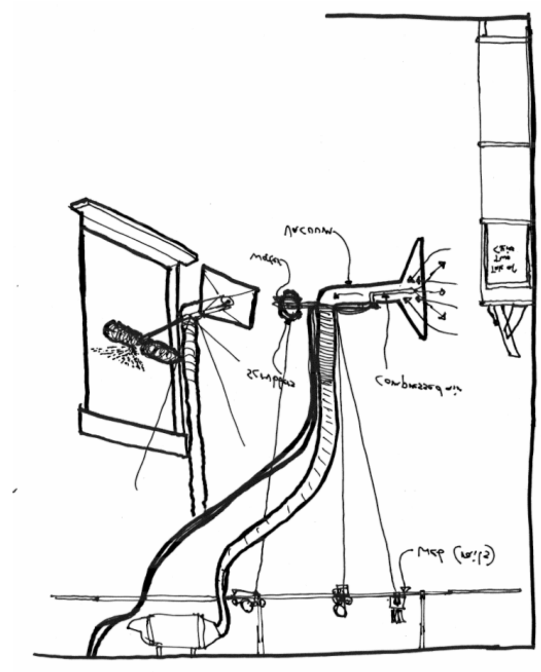
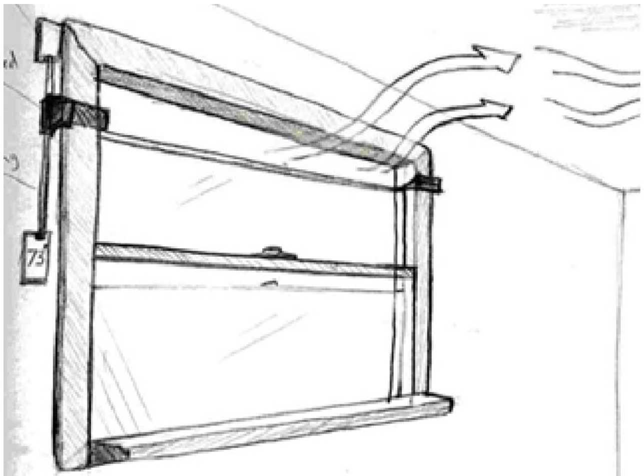


Figure 5. Exposed and intricate mechanisms depicted in a sketch showing a cleaning system for a home.

Appearance: Departing from the modernistic aesthetic

Robotic products are often sleek, modernistic forms. But underneath the stylized housings are complex mechanical structures and electronics, which themselves can be beautiful. Probe data showed a desire to show form and function together for home appliances. Interface and interaction design students responded with a desire to show the complex workings of robots in the home:

> "The human body allows for great reach. To achieve similar capabilities, for example for dusting, requires similarly complex kinetics in a robotic system. In this sketch a series of structures are mounted on ceiling tracks that allow for mobility. Rather than containing the robot in a single housing, each structure is mounted separately and hangs from the ceiling, naked and present in the room, exposing the mechanisms, not only so they can work, but also so the robot can be understood. The overall effect is an aesthetic of exposed infrastructure." (Figure 5).



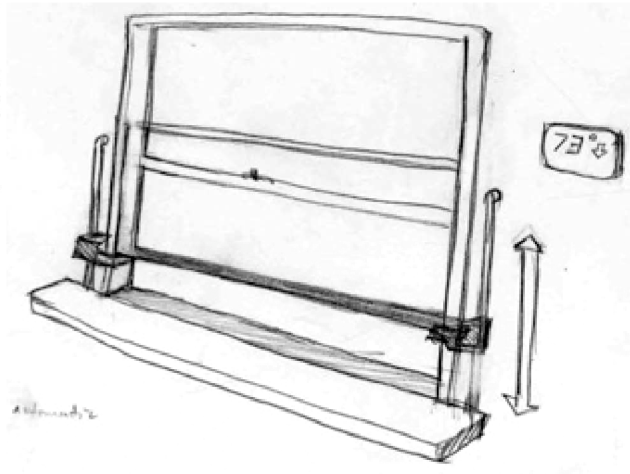


Figure 6 and 7. Retro-automation.

Function

Function refers to what the product does, and how. Designers used the whimsical desires from the probes data to help inform what robotic appliances should do.

The designs produced in relation to function were refreshing in their use of intricate, analog processes. Among the student teams, there were refreshingly few depictions of the usual PDA-type devices, which are so often found in interface, and interaction design class sketches. Rather than adopting the sleek features of today's home appliances, the student designer engaged with technology in a direct, physical manner, choosing to represent how the robot actually functions, rather than sketching a housing that mystified the underlying product function.

Retro-automation: Robotic technology placed in existing homes

Ubiquitous computing promises homes of the future that adapt to the wants and needs of the inhabitants and adjust themselves to environmental conditions. However, the probes data showed that many participants simply felt that their homes were too archaic for new technology. Designers responded with microsketches showing retrofitting with new autonomous devices, as conceived by the design student:

"One hundred year-old homes rarely have air conditioning systems installed. A challenge is keeping the air moving on a hot summer day. The first component of the robotic system is a series of fans that move themselves around the house. A second component is a series of mechanical robotic prosthetics for opening windows. These prosthetics are outfitted on windows in the summer just as plastic is sealed over the same windows in the winter. Throughout the course of the day, internal and external temperature variations and breezes are registered. From this information windows are automatically opened and closed to maximize airflow throughout the house." (Figure 6 and 7).

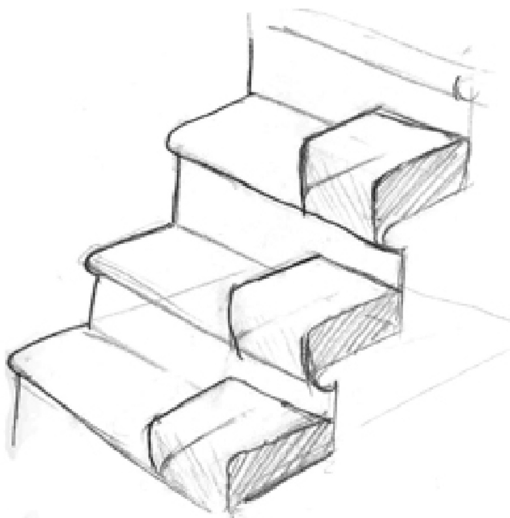


Figure 8. Robotic stairs alongside conventional stairs.

Figure 9. E-Bay robot keeps the attic tidy.

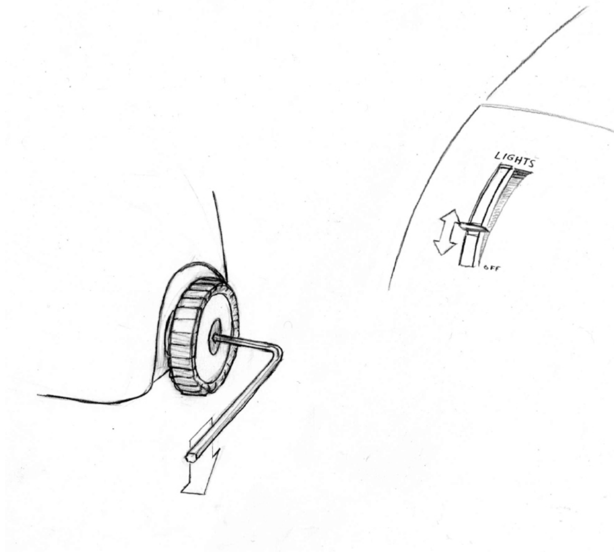


Figure 10 Calibration.

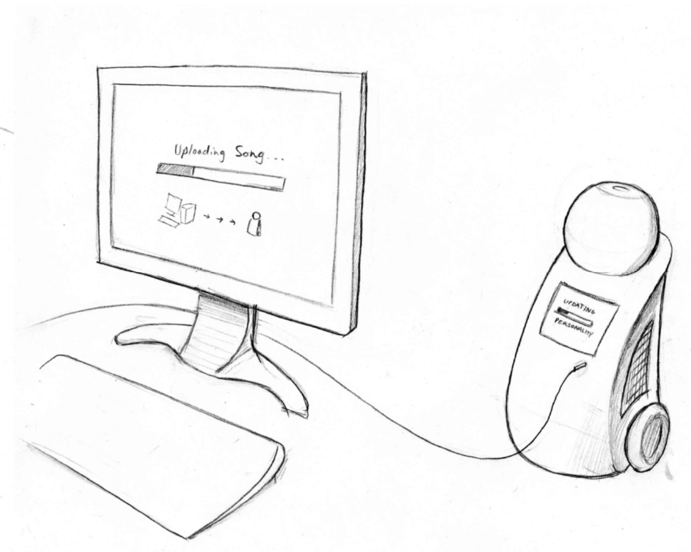


Figure 11. Tuning.

Adaptation: working with existing systems in the home
The probes depicted many issues in the home that caused breakdowns among family members: broken appliances, missing items, products that were no longer of use, and the like. Microsketches showed how robotic technology could be used to mediate these shortcomings. As described by the design student:

> "Stairs are difficult to remove, and challenging for the elderly, the infirm, or anyone carrying a heavy load. Installing elevators is rarely an option, and vertical chair lifts are unsightly. Rather, a second set of robotic stairs can be added, that would expand out from the first. These could be opened and retracted at will. In this way, each step would be half the normal distance and rise, making climbing the stairs that much easier." (Figure 8).

Another concept to deal with messy spaces and misplaced items in the home was developed by a team in the design class:

> "This product is a robot which readily goes into the attic, with the goals of cleaning the space where no one wants to go, finding lost items, and getting rid of unwanted items, perhaps by photographing them and listing them on e-Bay for sale." (Figure 9).

Interaction
Interaction refers to the various ways that people engage with the robot: the behavioral qualities that engage vision, hearing, and touch. In using probe data and microsketching to design the interaction, student teams were much more attentive to all of the senses involved in the interaction. The design student was able to conceive of details such as the personality and fine-tuning of the robot.

Personalization: ability to calibrate and tune the product
Probes data showed that people have an innate desire to personalize their favorite things. Calibration and tuning were depicted by designers as unique approaches to personalizing the robot. Calibration refers to setting the limits or specifics of how the robot operates. Interestingly, calibration methods played off of mechanical metaphors, even when what was being calibrated was a computational factor, as depicted by the design student:

> "When the robot is first brought home, the owners give it free reign to move around the house. But after some time, they decide they would like to limit the range and slow the speed of the robot. Rather than reprogramming the robot, these attributes are regulated by tightening the wheels with an Allen wrench and adjusting the lights with a dimmer switch. The robot is placed on the kitchen table and the couple sit down together to calibrate the robot to better work in their home. Once calibrated, they turn it on again and set it to work. Over time, the settings may slip, as they would with a mechanical device, and the robot will have to be recalibrated." (Figure 10).

Another concept that emerged was "tuning the robot." Tuning took on two meanings. The first was similar to the tuning of a car. In this sense, tuning was simply another term for calibration. The second use of term, however, was tuning as in the tuning of a radio. In this sense tuning became a way to personalize the robot through the choice of media, as depicted by the design student:

> "A robot is often seen as having a personality. Why not offer an alternative? Similar to how a stereo reflects the personality of the owner through what music it plays, so too could a robot. The robot could loaded with media — music, sounds, images, video —

that would be played back, displayed, or projected to exhibit a certain personality. The user could tune the robot to whatever media was most appropriate to construct the desired personality of the robot. In this way, the personality would be adjustable by multiple users and open to change over time.” (Figure 11).

Movement towards a final solution: refined sketches and prototypes

Inspired by the probes data, both the design student working in isolation and the class members, working in teams, were able to successfully employ the microsketching process to move from data to initial concept design. At the end of two weeks, student teams produced product concepts that were refined enough to suggest to an external audience what robots in the home might do, and how. The concepts from the design student were used to successfully progress our research, and have led to the design of a robot that delivers food and drink to various family members in the home, along with a revised concept for a home cleaning robot.

DISCUSSION

With the use of the microsketching technique, we hoped to leverage cultural probe data and accomplish the process of moving from existing research to viable concepts within our design brief. We believe that the microsketching technique proved useful on all accounts. Both the experienced designer and the student teams used microsketching to produce a series of novel and inventive ideas that might not have been arrived at if the task had to be conceive of a new robotic product in its entirety. Such tasks can be overwhelming for even a trained product designer. Instead, by focusing on parts instead of the whole, new forms, functions, and modes of interaction emerged independent of any larger product design or development agenda. The results of the microsketching exercises placed the focus on the creativity of designers, and empowered them to engage in the activity of design.

We believe that the results of the case study presented here have value beyond illustrating the benefits of the microsketching approach. They help to illustrate the leap between data collection and design. They help to reinforce the design culture within which these methods are situated [2, 17]. Finally, they help to reinforce the alternative ways that knowledge and understanding can be codified within the field of HCI.

A common theme that can be traced throughout all of the sketches is the leveraging of the familiar. Designers returned to well-familiar aesthetics, functions, and interaction techniques. One reason for this might be because robots are strange and unfamiliar both to designers and to the context of the home. Microsketches naturally drifted towards those devices and tactics that were comfortable and common, perhaps reiterating details discovered in the probe data. The familiar does not entirely overcome the unfamiliar, but instead makes technology manageable, because it provides a straightforward point of reference for potential users.

CONCLUSION AND FUTURE WORK

This paper has presented the microsketching method, which attempts to bridge the gap between rich, detailed data collection and final design. We have found microsketching to be a valuable method for rapidly generating focused design-centric explorations into as yet undesigned systems. The use of cultural probes as source material fostered the inventiveness of the sketches. While we have illustrated the microsketching method in the context of robotic products, we have found it to be successful in conceiving other interactive systems. By using the microsketching process, experts, novices, and those outside the discipline of design can begin to discover and invent elements of an interactive technology system.

The microsketching method is in keeping with a type of design research known as *research through design* [4]. In this model, designers act as integrators, seeking to understand elements that form wholes and contribute to research questions around a group of phenomena. A microsketch, or a proposed solution, offers a unique solution towards the problem that arises out of the group of phenomena — a “what if?” that advances the dialogue of design research. We have found that this type of design research situates well within the interaction design, HCI and HRI communities, because the artifacts created serve as ways of bridging the gap between theory, technological advances, and problems and situations observed in the world. Optimal conditions for using the method are when the solution is a new product or system that has never been designed before, and is so complex that traditional sketching activities well never reveal answers to the complexity.

Our future work is comprised of several efforts. First, we will continue to expand the source material that can be used for microsketching beyond cultural probes. We will also determine a set of specific constraints that might be used in sketching exercises. Many traditional design exercises are constructed around the manipulation of a limited number of elements [7]. These can be used to guide design process and creative exploration, resulting refinement and awareness of the possibilities and limitations of a given technique. Finally, we will run a field study comparing the microsketching technique to more traditional design ideation techniques. This will help to clarify the ways in which microsketching is effective.

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