

Designing Home Appliances for Older Adults

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Although computing technology has made inroads into home environments, it has yet to instigate a major shift in the design of homes or home activities. We posit that the next revolution of technology in the home will arise from technologies aimed at helping older adults maintain their independence and quality of life while helping avoid a transition to a more expensive, institutional setting. In this article, we describe three of our research projects that each tackle a different dimension to “aging in place.” In our work with the “Digital Family Portrait,” we examine the need for awareness between extended family members especially when family members are separated by great physical distance. In the “Cook’s Collage,” we investigate the use of activity snapshots to aid a person in resuming an interrupted task. And finally in “Dude’s Magic Box,” we explore ways to help grandchildren and grandparents communicate when face-to-face visits are rare.

Keywords: home, older adults, aging in place, ubiquitous computing, communication, memory

Homes change slowly. More specifically, the layers of homes change at different rates. The physical site for a home may remain unchanged for generations. The skin or shell of a home may last a decade or more, and the furnishings in a home change often in response to aesthetic trends and the availability of new appliances (Brand, 1994; Rodden & Benford, 2003).

Major shifts in emerging technologies can significantly alter the landscape of the home. Clearly household electricity, centralized heating, ventilation and cooling, and indoor plumbing have transformed the physical structure of the home, the activities within the home and the inclusion of fixtures and devices in the home. Although computing technology has made inroads into home environments, it has yet to instigate a

major shift in the design of homes or home activities. The convergence of television and the Internet is lagging expectations and the combination of desktop computers, entertainment consoles, televisions and cell phones has yet to form a cohesive whole.

One possibility is that these technologies do not meet a coherent need but only augment current entertainment and communication practices. We base our research on the premise that the next revolution of technology in the home will arise from technologies aimed at helping older adults maintain their independence and quality of life while helping avoid a transition to a more expensive, institutional setting. A coherent suite of technologies will eventually enable older adults to be proactive about their own health care, aid them in daily activities and help them learn new skills, will create new avenues for social communication and, of course, will help ensure their

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safety and well-being.

In this article, we describe three of our research projects that each tackle a different dimension to “aging in place.” In our work with the “Digital Family Portrait,” we examine the need for awareness between extended family members especially when family members are separated by great physical distance. In the “Cook’s Collage,” we investigate the use of activity snapshots to aid a person in resuming an interrupted task. And finally in “Dude’s Magic Box,” we explore ways to help grandchildren and grandparents communicate when face-to-face visits are rare.

Each of these projects is still in its infancy as it is likely that much time will pass before any of these devices would be commonplace. And evaluation outside of an authentic home experience is difficult and limited. However all of this work is grounded by field observations of real families and an iterative design process. We hope that this discussion will encourage others to investigate similar technologies that aid older adults in the pursuit of aging in place.

Background

Older adults prefer to “age-in-place”, to remain in their own homes for as long as they are able to take care of themselves (e.g., AARP, 2000; Shafer, 2000). From a societal perspective, it is also cost-effective to support their preference. Data from a study in the United Kingdom, for example, suggest that private residential living costs only 55% of the costs of full-time residential care (reviewed in Tang & Venables, 2000).

There are numerous challenges to “aging in place,” only some of which are being addressed by industrial and medical products. The most obvious needs are medical alerts for emergency response following a fall or medical crisis. However there are substantial needs in addition to preventing or responding to a crisis. In our research, we have focused on addressing needs in cognitive supports for daily activities and com-



Figure 1 Georgia Tech Broadband Institute Residential Laboratory (*Aware Home*)

munication supports for social connection and awareness.

Two of the three projects we describe rely on some form of sensing infrastructure in the home environment. At the Georgia Institute of Technology, this research is being conducted in the Broadband Institute Residential Laboratory (pictured in Figure 1). This house, referred to as the *Aware Home*, is approximately 5000 gross square feet, and has two identical floors, each equivalent to a typical three-bedroom apartment, allowing comparison studies. It is built with all the functional and design requirements of a normal home, as well as with facilities for instrumenting each and every room with sensors and displays to support ubiquitous interactions between the residents and the house. As part of a multi-disciplinary group of researchers, we are installing a wide range of sensing equipment (cameras, microphones, infrared, radio frequency, sonar, tactile), including general metering on utilities, as well as specific instrumentation on appliances. The goal is to automatically and unobtrusively measure activities of the residents and provide support for their daily needs and activities.

Digital Family Portrait

The desire of older adults to remain in the familiar setting of their family home frequently must be balanced with their extended family’s



Figure 2 Digital Family Portrait

desire to keep them safe. Clearly this balance becomes more precarious as age increases (Naleppa, 1996). Geographic distance between extended family members exacerbates the problem by denying the casual daily contact that naturally occurs when families are co-located (Mynatt, Rowan, Craighill, & Jacobs, 2001).

The Digital Family Portrait is an in-home monitoring system to inform family members about an older relative's daily activities, health status, and potential problems, as well as information about patterns of activities over a period of time. The Digital Family Portrait creates a visualization of the older person's day at home from available sensor information and displays the information to a family member in a different location. We designed our current prototype by framing a flat panel display and connecting it to a standard personal computer. Various sensing technologies (e.g. radio frequency badge tracking and computer vision) can gather information about the individual pictured on the display and be integrated into the interface. The current design presents iconic imagery summarizing four weeks of daily, household life.

Shown in Figure 2, the default display of the Digital Family Portrait illustrates the relative activity levels of the older woman pictured in the

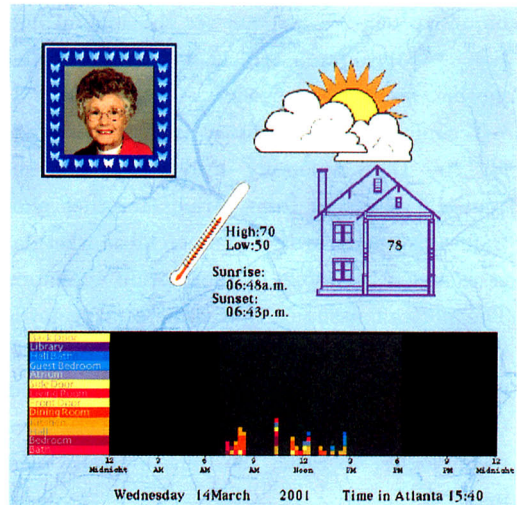


Figure 3 Digital Family Portrait Day Detail

center. Each butterfly depicts one day of information. The current day is white and time proceeds clockwise around the frame. Four activity levels can be differentially depicted. The portrait is designed to be persistently displayed in a home environment and to be interpreted with minimal effort.

By touching the butterfly for a particular day, the viewer can see more details about that day and that individual. As shown in Figure 3, the detail screen includes information about the weather at that location as well as the indoor and outdoor temperatures. These simple pieces of information can be significant in assessing someone's behavior; for example, having a slow day when it is raining outside. For this portrait, the woman's activity is measured based on her movements between rooms, in her home. This information is summarized in the bar graph shown at the bottom of the screen. Rooms are color-coded and the number of transitions is summarized in fifteen-minute intervals. Daylight and nighttime hours are indicated via the background shading. Although these details are available, the visualization can also be quickly read, for example, noting numerous trips to the bathroom during the night, or perusing the overall flow to the day. We are currently experimenting with tech-

niques to help viewers answer the general question: "Was today a typical day for my [father, mother, aunt, grandmother ...] ? "

Technically, the hardware configuration used for the Digital Family Portrait is not substantially different from various Internet photo frames available in the commercial marketplace as well as other forms of information appliances. The portrait assumes that some sensing infrastructure is available and that the information from the sensors can be transmitted to the portrait, including the use of encrypted Internet technologies, to reach the remote family members.

The main design goal of the Digital Family Portrait is to support awareness of the long-term health, activity, and social well-being of senior adults living by themselves, answering questions such as "Has she been eating enough?" and "Is he active or sedentary?" For example, a display on an adult child's bookcase could provide a qualitative sense of the activity of his elderly mother. Our research indicates that this day-to-day awareness is key to providing peace of mind for family members concerned about an elderly relative who potentially lives far away from them.

Most awareness interfaces only provide a snapshot of the present. However, many questions about an elderly parent refer to trends over time, such as "Is she becoming more socially isolated?" or "Have his movements been dramatically reduced since he had that fall?" Consequently, the Digital Family Portrait provides representations of the past, as well as the present.

To meet emotional and social needs in addition to pure informational needs, the Digital Family Portrait is designed to provide appropriate assurance without triggering additional anxiety. For this reason, colors in the visual display are not associated with changes in the well-being of the older adult, such as the display fading to a dismal gray on a bad day. Socially, the portrait is designed to play a role in family communication and awareness, but not to portray a

complete and medically official record. As the sensing infrastructure will only have incomplete knowledge about the senior adult, its visual display should mirror that uncertainty. A regrettable unintended consequence of a portrait that attempted to present an all-encompassing depiction of someone's life would be the reduction of other social means for care-taking such as phone calls and paying attention to outside events, such as the death of a friend, that influence daily behavior.

In this research, we have combined field observations and interviews, iterative design, empirical evaluations and field trials with the prototype portraits to create an interface that conveys salient aspects of everyday life, complements existing communication practices, creates an emotionally-engaging experience, and respects self-presentation and privacy needs (Mynatt et al., 2001). Beginning in the fall of 2003, we will start a field trial of a fully-deployed Digital Family Portrait that will also be based on sensing physical movement throughout the house. We will be able to track the use and experience of an older woman and her adult son as the sensors in her home generate data for the portrait visible in his home. We will also get a rare picture of daily home life even if from a limited perspective.

Cook's Collage

Two common cognitive declines that accompany aging are forms of memory: 1) working memory, that is, the ability to maintain information actively as it is being processed, and 2) episodic memory which is the ability to store new memories of events (Zacks, Hasher, & Li, 2000). Together these impairments impact an individual's ability to perform, particularly to complete, common household tasks (Smith, 2001). Many daily life activities rely on these memory processes and the consequences of age-related declines may be exacerbated if the older individual is distracted or interrupted. Simple examples

include remembering whether detergent has already been added to the laundry, if the bathtub water has been turned on, which ingredients have been added to the dinner being prepared, and so on. Moreover, younger adults may experience memory problems when distracted, interrupted or faced with competing demands for attention.

A strategy for minimizing impairments in performance due to memory deficits is to provide records of recent actions that serve as a surrogate memory enabling an individual to resume an interrupted task. This recording function is a reasonable task for computational support as computers can be programmed to visually capture a series of events, and even select key frames to depict those events, without needing to understand those events or provide prospective memory support by identifying likely goals.

We opted to explore memory lapses during a common household task, cooking. Cooking is a physical activity that is subject to distractions and interruptions. Mistakes are costly but, for the most part, are not life-threatening. The process is made up of specific activities (e.g. add a cup of flour) but rote cooking from a recipe is not the norm. Hence a predictive system (e.g. “next, do this”) could often be wrong, but a capture system (e.g. “here’s what you’ve been doing”) could aid a user in remembering specific actions.

Our current prototype system, called “Cook’s Collage?” provides surrogate memory support for general cooking tasks. The current design emphasizes the temporal order of cooking events. Visual snapshots of cooking actions are arranged as a series of panels similar to a comic strip. Cameras are mounted in several unobtrusive locations, such as beneath a cabinet, overlooking a countertop. Visual snapshots from this angle emphasize the detailed activity of hands and objects while minimizing content, such as faces, that often exacerbates privacy concerns and general discomfort with visual sensing. As shown in Figure 4, six images are shown in order with the upper left being the oldest and the lower right

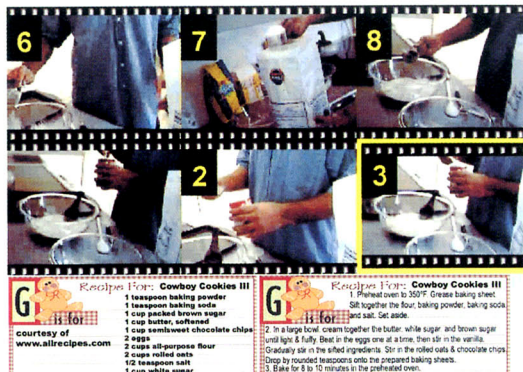


Figure 4 Cook’s Collage

being the most recent. Counts of specific activities, such as adding a cup of flour, are shown in the upper left corner for each snapshot.

It is unclear whether a simple temporal ordering of images is the best organization to support memory. Other arrangements are possible. Cooking is organized both spatially and temporally, and, although potentially guided by a recipe, people often improvise both in the order and form of their actions (Suchman, 1987). A spatial arrangement could mirror, and thus reinforce, the user’s spatial division of work. For example, multiple displays could be directly associated with certain physical locations, such as the stovetop, left or right countertop, or the refrigerator. Another option is a semantic arrangement based on classes of cooking actions, such as grouping together images associated with heating, chopping, cleaning, and measuring, respectively.

The primary goal of the system is to provide an ongoing record of recent cooking activity. Its design is motivated by Norman’s distinction between knowledge in the head and knowledge in the world (Norman, 1988). By adding information to the world in the form of a visual record, the system decreases the cognitive demands of the cooking task, namely the recall of recent actions. Ideally, users would integrate these snapshots with existing information in the world, such as discarded eggshells or a measuring cup with a trace of flour, so that with little conscious effort,

they would fill in any gaps in their retrospective memory. A less-than-ideal, but still workable system, would require the users to interact with the display to retrieve greater detail about past actions. For example, by selecting an image of the act of measuring sugar, the user could determine that two, but not three, cups of sugar had been added to the mix of ingredients.

Laboratory-style evaluations of the Cook's Collage have been mixed. When participants, making cookie dough as instructed, are interrupted, they do make critical cooking mistakes. However users have to be proactive in their use of the display. It does not alert them to a mistaken step. For those users that do glance at the display for assistance, the video stills seem to be easy to comprehend quickly and provide useful information. We are currently investigating variations on this prototype to determine how to best support the demands of particular tasks.

Dude's Magic Box and Picture Desk

Just as the absence of peace of mind that rises from not knowing an aging parent's well being poses a threat to that parent's ability to age in place, the social isolation that frequently accompanies aging also poses a threat to an aging adult's ability to age in place. Both of these social communication issues are brought on by distance, the former being social communication that affects the peace of mind on the part of the adult child, the latter of which affects the level of social isolation experienced by the aging adult.

In the United States and other industrialized countries, it is uncommon for grandparents and grandchildren to live in close proximity to one another. Unfortunately grandparents are deprived their traditional societal role of caring for the grandchildren, a role that kept them in contact with their extended family and reduced the sense of social isolation. An additional unfortunate result of this distance is that the grandchildren are deprived of their grandparent's audience, a valuable resource that affects the grandchildren's

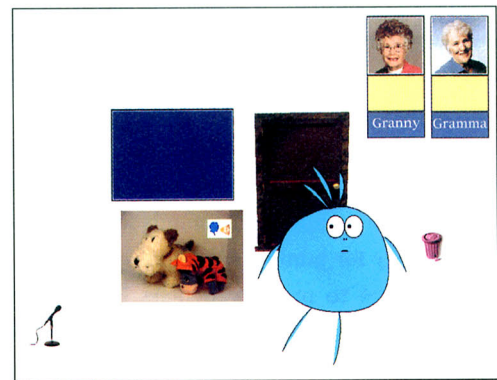


Figure 5 Dude's Magic Box (Screen)

constructions.

Dude's Magic Box and Picture Desk support social communication between a grandchild and a grandparent by enabling young grandchildren to share objects with an interested grandparent living at a distance. Briefly, the box takes pictures of its contents and the children can annotate those images with voice recordings before sending them to their grandparents. By producing images of these objects, supporting voice-recorded annotations to those objects and allowing each party to interact with these objects on their own time schedule, this technology allows grandchildren to share things from their daily life experience with their grandparents. In so doing, this technology supports social communication in a way that decreases social isolation on the part of the grandparents by providing a means for regular contact with their grandchildren. Additionally it encourages the grandchildren to interact with their grandparents through objects by providing an authentic (though remote) audience for their constructions.

Dude's Magic Box and Picture Desk are two pieces of technology that are designed for and intended to be used by two people from nearly opposite ends of the life spectrum. Their interests and abilities are sufficiently different to suggest that the mechanisms used to support the proposed social communication should be different in form factor, capability and in function. Start-

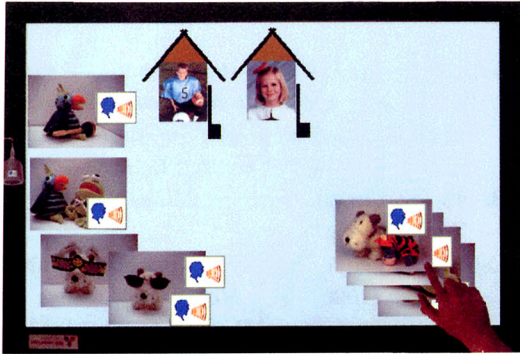


Figure 6 Lap Desk for Grandparents

ing from Csikszentmihalyi's "The Meaning of Things," it is clear that older adults, the grandparents, would hold images that come from the grandchildren in high regard while the younger generation, the grandchildren, would not regard images coming from the grandparents as having value. The grandchildren, on the other hand, prefer objects, things that can be manipulated, and communicate using these objects as props.

Dude's Magic Box is comprised of a touch-sensitive display on the box's lid, an embedded wireless computer and a camera within a box. The box itself is designed in a way that allows it to make images of not only three dimensional objects like toys and frogs, but also flat things like drawings and school papers which can be hung against the back wall.

In addition to the physical aspects of the box, it has the "back-story" of being inhabited by an animated character called Dude. The initial decision to include an animated character rose from our a desire to provide objects of interest for the grandchild to manipulate and to make the box more fun to use; giving it value to the grandchild in the hope that this would encourage use. This character "lives" in the world shown on the display, speaks in a simulated human voice and pays "attention" to what is going on in his world. Additionally, this character acts as an envoy to the grandparents ferrying the grandchild's constructions to the grandparents as well as bringing back the grandparents' responses. The charac-

ter's ferrying constructions back and forth opens an interesting opportunity to use this character as a conveyor of context between the communicating parties. For example, returning from grandpa's, Dude may be carrying an umbrella to indicate that it is raining at grandpa's house. In the grandparent's home, Grandparent's Picture Desk is a flat display on which the grandchild's constructions can be reviewed, played and shared with visitors. Figure 6 shows that the surface also provides the grandparents with the ability to record their own voice, add that recording to the constructions received from the grandchild, and send it back to the grandchild.

We are just starting focus group evaluations of these communication technologies with older adults and young children. We are interested to see whether older adults think that these technologies are of value to them and to see what children will opt to put in the box. As these technologies do not require a sensing infrastructure, we are hopeful to be able to conduct substantial field studies in the near future.

Conclusions

Melenhorst and her colleagues (2001) investigated the attitudes of older adults toward new communication technologies by focusing on the perceived benefits instead of emphasizing the stereotypical resistance and phobia of older adults regarding advanced technologies. This study, as well as research regarding older adults using the Internet (Mynatt, Adler, Ito, Linde, & O'Day, 1999), sheds light on the almost straightforward adoption of technologies by older adults once they perceive a real value. However, if the value is not apparent, a low cost in either money or time will not sway their negative opinion.

Once a technology's value is apparent, older adults will undertake sophisticated reasoning regarding its costs and benefits. For the systems described in this paper, privacy is a potential stumbling block. In the Digital Family Portrait, a sensing infrastructure collects informa-

tion about an older adult and then transmits a representation of that information to extended family members. When discussing this design with older adults, however, they are quick to point to the loss of privacy that occurs in an institutional setting. Moreover the visualization by the Digital Family Portrait is an abstraction and preserves many aspects of privacy as it does not depict what a person looks like or exactly what they are doing.

Another issue is control. Having machines dictate human activity is no better than adults dictating human activity. Hence the Cook's Collage does not try to tell a user how to cook, but attempts to aid the cooking activity by minimizing the impact of distraction and interruptions. Of course some technologies, such as medication reminders, cannot be so flexible. However there is a great difference between a technology that helps a person remember to take medication and one that implicitly orders a person to take medication immediately. Both can achieve the same goal but the former is much more likely to be successfully adopted by an older adult.

There are numerous other factors that influence the successful adoption of home technologies by older adults. As the sheer number of older adults increases, it will be feasible to construct products specifically for this demographic group. There is little reason to expect that a young child, a young adult and a senior adult will want to use the same communication technologies even to communicate with each other. As computing technologies further inhabit homes, its user base will have widened dramatically. Thus the next round of technology revolution in the home foretells the next revolution in computing technologies as well.

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