[very good paper. It was well written, clear, and gave very good coverage of the background and for the user interface of your system and the underlying rationale. Excellent job!]
Smart Homes for the Aging

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Introduction

Smart Homes are traditionally defined as bringing all your devices and appliances together so that they can communicate in a centralized way. Implementation of smart home technology is becoming more and more frequent in order to allow the elderly to maintain their independence and provide a safe environment for them to live in. A major advantage of current smart home technology allows for the elderly to stay in touch with and connected to their families at all times and from any location. Another advantage of implementing smart home technology is that it relieves the stress of transitioning to an elderly home and can help delay that transition for a considerable amount of time (Cheek 2005).

A major concern for potential elderly smart home users is the replacement of personal caregivers by technology or a lack of human responders (Cheek 2005).[what is the nature of the concern here?] A key challenge when designing a smart house is including every single device and appliance and yet still having an interface that is not overly complicated. Another challenge faced by smart home designers is the best way to keep the interface mobile so that when the user would like to change something they do not need to walk over to the control panel on the wall or carry a clunky device around.[are these design decisions that you believe are important and necessary to

consider, or are they things that others have also highlighted as important and problematic? Do other, competing solutions suffer from such poor design decisions?] Attempting to keep costs low when developing a smart home system is another big challenge faced because current technology is expensive and development costs can also be very high. Often times when dealing with the elderly, anxiety arising from the use of new or unfamiliar devices or interfaces can make smart home implementation very challenging. There are two challenges related to this phenomenon. The first challenge is that it is often difficult for the designer to put themselves in the perceptual world of the elderly smart home user. The second challenge is the ability of the designer to convince the technophobe that the design is truly useful (Sponselee et al. 2008).

One key theme when designing a smart home interface that shows up often in the literature is that the designers need to be goal oriented (Sponselee et al. 2008).[what is meant by goal oriented? Do you mean in their design decisions about what to include, or in who does what in the actual implementation?] Our primary goal as smart home interface designers was to rethink current smart home interfaces and to come up with a new, simple interface that would allow for elderly users to interact with their homes in a meaningful way. Our secondary goal was to come up with a design that is seen as something that augments but does not replace human care. “Designs should place the user in control and automate only to ‘improve system performance, without reducing human involvement.’ ” (Shneiderman 2010). The last of our groups’ major goals is to design easy to use technology that will ultimately improve quality of living for the elderly while maintaining a high level of safety through accident prevention, emergency response, and offsite monitoring by caregivers and family.

Our persona, John, is an elderly veteran who has experienced significant physical hardships in his life and his body is now paying the price in his old age. He has significant joint pain, hearing loss, and slight vision deterioration. When considering our persona we decided to isolate some common physical conditions that the elderly struggle with. However, we realized the elderly population deal with many forms of physical and mental ailments which we attempt to address with our design. We are clearly not shooting for universal design as defined, but under our specific goals of designing for the elderly we need to encompass as much of that target end user audience as possible. So when talking about issues an elderly user would face in their home it was in our best interest to think of these issues more generally to start, and then apply the persona to storyboards and prototypes. The few big generalized issues we wanted to address when considering elderly users were as follows: poor eyesight, mobility problems, and the ability to recall information. Designing around these few big issues allowed us to meet the needs of a large portion of the elderly population that is on the cusp of losing their independence. All of these issues that the elderly face played important roles in smart home design.

Technology and Literature Review

There is a decent amount of smart home technology currently present in the marketplace. Most current smart home technologies are associated with luxury features for the standard issue models out there. Savant (savantsystems.com) is a good example of current smart home technology that is offered to consumers. They offer a system heavily integrated with Apple products that offer a lot of luxury/lazy features.

Elderly people who move to a care facility often show a great regression in their functioning and their abilities, due to the increased support in comparison with the home situation.[Is this something you found in the literature or your own conjecture? What changes?] One of the goals of the caregivers should therefore be the continuation and stimulation of the independence and autonomy of the care receiver (Sponselee et al. 2008). We were primarily focused on the important features that promote independence for the elderly (and promote a healthy/active lifestyle), while still incorporating some popular yet practical luxury features that are common to most systems today. We have included luxury features like lighting control, music, temperature control, and bed control. We should note though that the overall direction of smart home design is going in a slightly different way. In new designs, the homes are filled with sensors that monitor every move and person in the house along with all devices and appliances. Our group set out to establish the best interface design that would include as many appliances that would be essential for an elderly person without becoming overly complicated.

Smart home technology that is designed for the elderly user is generally more focused on medical purposes and monitoring systems. These monitoring systems implement hundreds of sensors and often video cameras (Chan et al. 2009) to monitor activity in the home. The sensors are often used to fully automate the technologies in the house and as a result give the users less control. Designing for the technophobic elderly, we actively made the decision to create a smart house that is, less smart (accomplished by removing fluff features which cause laziness and ultimately dependence). [I like this approach as it avoids the “crutch effect”. Was this something that your group thought was going to be a problem, so you were being proactive, or was

this something brought up as an existing problem in the literature?] While the smart technology may not be fully automated for the user we still wanted a certain level of smart technology that is concerned with the development of a system which adapts to user needs, expectations, and goals (Callejas and López-Cózar 2009). In other words, as we design for the elderly, we make sure “not to impose human operator actions (requirements) onto the user-interface” (Shneiderman 2010). The smart house will essentially save specific preferences for each user by logging routines and desired settings which the system will adapt default settings for.

Our approach is to design a system that does not replace human interaction. It will allow for users to have direct contact with offsite care providers and family members but at the same time give them the tools that allow them to keep their independence. Another key “feature” of current smart home technologies on the market are the incredibly high prices. We sought to ensure that during the design process we were excluding fluff features that are common place in normal smart home designs but which ultimately bring the price of the system up, and overall usability for the elderly down.[it would have been good to give some examples of the features that you are referring to here, as well as sample cost of such systems.]

Our design seeks to, literally, put control of the smart house features into the user’s hands through use of mobile touchscreen tablet technology. A touchscreen interface makes use of direct mapping which is more intuitive and easy to learn (Caprani et al. 2012) for new users and actually encourages exploration (Hollinworth 2009). Touchscreen interfaces are less physically demanding with the use of simple hand gestures enabling almost all features to be accessed with a single finger allowing

for a much wider range of users that may suffer from physical limitations. This low physical demand is important in creating a universal design (Dix 2010). [I agree and think this design decision is a good one on your part.] Most of the current touchscreen interfaces are primarily point and click and often have small screen objects that are close together rendering the interface unwieldy (Hollinworth 2009). Our interface makes use of large buttons with inverse polarity color schemes of light text on dark backgrounds (Shneiderman 2010). This design benefits users with physical and visual impairments alike. [good use of HCI principles. What about color scheme?] To further develop our multi-modal approach the use of tactile response for all interface buttons is implemented to provide feedback for vision impaired users through the use of auditory (i.e clicks) and haptic feedback (i.e. vibrations). This output provides positive sensory feedback and has been shown to improve performance for elderly users (Caprani et al. 2012) and is also a consideration for the universal user (Dix 2010). While we believe the use of a mobile touchscreen tablet will be beneficial for elderly users, we realize that carrying around such a device at all times would be impractical and limited. For this reason, we designed a comparable wearable interface device that makes use of the same multi-modal input/output features.

Wearable smart home interfaces are not a new idea but are something that we really wanted to pull off. Wearable systems are not suited to those who are not mentally or physically able to operate them, as most wearable systems require a limited amount of user interaction to maintain and operate them (Scanaill et al. 2006). Knowing we had this challenge to face and also that there really is not much wearable smart home technology out there, we set out to think of some existing technology that could be

leveraged in a way not considered before. The technology that we settled on is the proximity technology offered by today's car keys (RFID's). This technology allows users to do things in a smart home that is currently not possible. The biggest advantage of this technology is that now a user does not have to carry a device with them or return to a hub to control their house.

The available literature for smart home technologies largely focuses on the current available technology and not much is specifically geared towards the elderly. Very little information is available on the practicality of current technology for the elderly (Morris et al. 2012) though we realize the importance of ethnographic observation (Shneiderman 2010). We were able to find one case study conducted by Callejas and López-Cózar (2009) which surveyed 200 men and women ranging in age from 50-80. The survey helped show different technologies that elderly users are interested in and would most likely find useful for everyday activities. However, the scope of the survey was limited to general technology categories such as music, TV, temperature control, etc.

We had difficulty finding any information on evaluation of in home sensor technologies especially from an elderly perspective. However Sponselee et al. (2008) discusses some studies that have shown that people in need of care are willing to lose some privacy if they get more independence or quality of life in return. Sponselee et al. (2008) have also shown in their studies that "the use of a non-stigmatizing device to attach to a wanderer [elderly] (an inconspicuous device should, for instance, resemble a necklace or a watch)" to track the users location, "the elderly focus group was less reluctant towards using an implanted chip than expected." Our watch interface took this

finding and included an optional GPS tracking device for caregivers and families to monitor current location of the elderly user from anywhere. However, any long-term monitoring that intrudes on the elderly users' private life must be minimized as much as possible (Scanaill et al. 2006). We believe that our communication design through the use of telephone and video calling will optimize privacy while maintaining a sense of security by providing a means of immediate contact from caregivers and family members. This line of communication will mean less reliance on the use of GPS technology and continuous distance monitoring.

Morris et al. (2012) discusses a previous study which discovered that elderly people that were trained to use technology were able to maintain cognitive ability to successfully use and learn smart home interface designs. This use of recognition through training is implemented in our system through multiple ways such as detailed video tutorials and technical assistance as well as direct contact with care providers and family members for assistance. In addition to these help features, direct training will be optional for new elderly users by company representatives that will be geared specifically for each house and user.[excellent lit review and motivation for your project!]

Design Description

Our design has two major user interfaces; the smartwatch and the touch screen tablet. The smartwatch is more simplistic, and with that simplicity, it does not carry quite as much functionality as our tablet. The smartwatch works using proximity and wireless technologies and acts almost like a "magic key" for any smart functionality. The touch screen interface is an application that can be put on any touch screen device such as an iPad, Samsung, or any other supporting mobile device. It covers the full range of abilities and is more in-depth and complex

than the smart watch. We ultimately made the design choice to include two interfaces to interact with the smart house because we felt that a tablet interface was too demanding to ask an elderly person to remember to carry around 24/7. If we give the tablet more advanced functionality but do not require it for the more commonly used tasks, and we make those functions redundant on the watch, then we eliminate their need to carry the tablet around.

SmartWatch Interface

The smartwatch device is much like a normal watch but with a larger than average digital display screen and strap for the wrist. The larger digital screen was a purposeful design choice to ensure those with poor eyesight could use our device. The display screen also utilizes inverse lighting (dark background with light text) to assist with eyestrain (Shneiderman 2010). It has several buttons; on, off, function, call and glow. These buttons are large, tactile, easy to press, and offer auditory feedback with adequate spacing between buttons. All these buttons basically include multimodal feedback which is a best design practice. The buttons are also self-explanatory in what they do with regards to what you are in proximity to or on the function of. Our design considerations covered several universal principles including guidelines on intuition and size and spacing (Dix 2010).

The watch also has a crankable “wheel” that goes around the face of the watch which interacts with most appliances (shower, lights, music, shades, doors, car and microwave to name some of the more common ones). The circular crank offers both tactile and auditory feedback for every slight rotation the crank makes in both clockwise and counterclockwise directions. This dual feedback takes into mind that redundancy of information is important (Dix 2010). The circular crank is a solid design for several

reasons but mainly because for most devices the crank is a sort of direct interaction. If you are interacting with the lights, it behaves just like a dimmer switch; if you are interacting with the temperature of your shower water, it is just like a thermostat. [this is an interesting and creative idea.] The crank wheel also works like the thermostat if the user was controlling the temperature of the room (heating and cooling). The way the crank works for the microwave would be that every “crank” of the wheel adds 15 seconds to the timer on the microwave and then they would select the on button to start it (“on” wouldn’t work if the door was open!). The way that the watch interacts with devices that it is not immediately in proximity of is by using the function key. Once pressed the user can either use the wheel to crank through the appliances they have available or say the appliance they want to control, “blinds” for example. The function list is populated completely upon install and can be updated and changed on the tablet interface. The call button functions very similarly to the function button. They select the call button and can either “crank” through their contacts (which again are populated and controlled on the tablet) or they can say the name of the contact they want to call. The smartwatch functions basically as a cellphone that is always on speaker. Another feature we have built into the watch is the ability for it to be a proximity key for your car (and functions exactly the same). This technology does not replace the key but rather complements it. Home security also works similarly to the car key. If you are by an exterior door (or select it from the function list from anywhere) and you use the “on” button, it will arm the house and lock the door. Again the goal is not to replace existing technologies but to create a redundant piece of technology that is simple to use and easy to recognize. One challenge of the proximity feature is the risk of being too close

to multiple devices, but by using RFID technologies, we can limit the effective range to around five feet which would make the chance of overlap 0% (and RFID's can operate on different frequencies). It is important to note that the general "functionality" of the watch is similar for all appliances that use it, which is part of our goal in keeping the technology simple.[I agree in this design philosophy.] An additional piece of technology in the smartwatch is a completely optional GPS locator chip. If requested, our watch interface can be fitted with this tracker and care providers and family members can monitor the elderly persons location. The GPS locator can also be used to locate the watch on the tablet interface should the user end up losing or misplacing the watch. The final piece of technology included in the watch is gyro technology that can sense falls. If this technology is turned on (controlled on the tablet), anytime the technology senses a fall, it will immediately send out a message to a primary care person at which point they can call the watch and ensure that the user is okay.

One of the biggest advantages that the smartwatch interface offers is that it creates a common interface with which a user can interact with theoretically any device that can work within our engineering limits. This provides any user a single way to interact with almost 100% of the devices in their home. Combine that with the fact that the watch is small, easy to use, and syncs with our tablet interface, and we have a pretty unique and new smart home interface design not currently offered on the market.

Touch Screen Tablet Interface

The touch screen application, as mentioned, can be used on a variety of touch screen devices, allowing to accommodate for different types of hardware. The application is organized by categories of tasks (Shneiderman 2010), and the display is

consistent with a dark background and light text for ease of sight (Shneiderman 2010). To further reduce visual fatigue the interface makes use of large font size and large previews which also have been shown to increase performance and reduce errors (Caprani et al. 2012).[How large is the font—what is the actual font type?] In our choice of the display, we made sure to consider proper and consistent color schemes and fonts to aid new users with navigating the interface (Caprani et al. 2012). [what colors?] It would have been very easy to make a flashy attractive interface with a multitude of options, but given the target end user, we decided to simplify and minimize as much as possible to avoid confusing screen clutter (Caprani et al. 2012). The interface also uses terminology and icons that are easily recognizable to an elderly person to reduce anxiety and confusion.

We divided the available options of the touch screen applications into seven major categories: smart house options, help, call, lights, temperature control, security system, and feature list since this organization is common and easy to follow (Shneiderman 2010). Each of these categories are displayed on the main menu screen as a large blue button evenly spaced and not within close proximity to each other, leading to another page/section of the application which will be discussed in more detail in the following paragraphs. In addition to these options, the main menu will have a 'System Status' bar located at the very top of the home screen. This will allow users to view the current state of the smart house and all active features in one display. To avoid screen clutter, this display can be collapsed and opened by simply tapping the 'System Status' bar. Realizing that the features available within this application are sensitive, especially the alarm system, the Smart Home application uses biometric fingerprint

identification (secondarily to the smartwatch), which is set up for all new users during initial training with tech representatives.

To further reduce anxiety and confusion, we designed a simple to learn button convention to help prevent errors and the ability to easily backtrack if errors are made. We placed a lot of emphasis on this part of the interface, knowing that elderly people are aware of their cognitive limitations when it comes to working with technology, which makes them more afraid to make mistakes (Sponselee et al. 2008). By providing clear documentation we lower the fear of novel devices and applications (Shneiderman 2010). With the exception of the main menu, all major option menus will have a ‘Main Menu’ and all extended menus will have a ‘Back’ button that is clearly labeled with light text on a blue colored left pointing arrow icon to signify the option to go back. All selectable buttons are symbolized by either a blue color background with the word ‘On’ in light colored text which signifies that it is currently active or with black color background and white button outline with the word ‘Off’ in light colored text signifying it is currently inactive. Buttons that are not selectable or disabled will appear with gray color background with light gray text. In addition to these buttons conventions, confirmation screens will display when a selection to change a system status has been made. These confirmation screens will plainly ask if the user would like to proceed with the selection made with the option to select either ‘Yes’ or ‘No’. This will give the user more control to either go forward with their selection or backtrack out of the selection if they made an error.

The ‘Smart House Options’ button will allow for system setup geared specifically for unique users. The setup will register users through personal identification forms and

a unique pin that will be assigned for each user. This setup will normally be done during the training for users with caregivers and family members present. Within the options menu, the ‘System Activation’ will be available. This option allows users to turn the smart house system on or off giving the user more control of the system as a whole.

Back on the home screen, users will see the ‘Help’ button. This button will call up the options to view detailed video tutorials geared specific to each house, view PDF help guides, visit the smart house help website, and use the ‘Find My Watch’ locator. The video tutorials will be displayed with descriptive titles placed above each play screen in a YouTube type format. The videos can be played by tapping once on the play screen. The videos will have detailed demonstrations of the use of the smartwatch and touch screen interface as well as all available smart house features. For more in-depth documentation on the available smart house features, PDF help guides are also easily accessible. Users can tap once on any desired descriptive title button to bring up the documentation. In addition to the video tutorials and documentation, the users can visit the smart house help website by simply tapping once on the button to call it up. The website provides users with some detailed options such as viewing FAQs, chatting with a representative, and getting additional contact information. The hope with implementing redundant ways to give users guidance is to properly introduce the new technology in a way that is not overwhelming and will give the elderly users a positive view as well as show them the benefits of it (Sponselee et al. 2008). The last feature in the help menu is the ‘Find My Watch’ button. If the elderly user has misplaced their watch, they can simply tap this button which will call up a locator map showing the current location of the missing watch. This makes use of the GPS technology built into

the watch to help locate and retrieve the watch. When this feature is activated the smartwatch will also emit an audible sweeping beep (that fluctuates in length and pitch from high to low frequency) to help users locate it. These features on the smartwatch are wired to run off a small auxiliary power source in the watch in cases when the main battery life is depleted.

Continuing on with the main menu options, the ‘Call’ button with bring up the following options:, ‘Emergency Call’, ‘Call Caregiver’, ‘Personal Contact List’, and ‘Call Smart House Helpline’. All contact information can be entered or edited within this interface. The contact lists and call options are also synced to the smartwatch interface which will auto update if any changes are made. All calls can be made by simply tapping on the desired contact which will then bring up a screen with the option to ‘Call contact’ and also has contact information listed below which can be edited.

The ‘Call Smart House Helpline’ allows users to place a toll-free call to communicate directly to tech representatives for the smart house company that can assist with any question. Depending on the severity of the issue, the tech representatives can either walk through solutions over the phone or they can dispatch technicians to the house.

The ‘Emergency Call’ button will bring up a contact list with essential numbers such as 911, the local police, the fire department, doctors, etc. This provides an easy way for the elderly to get immediate emergency assistance without having to remember contact numbers or complex button combinations during stressful situations.

The ‘Call Caregiver’ button will connect a call to the on call caregiver. The idea here is to have the on duty caregiver have a company cell phone on them at all times.

When the caregiver is not checking in at the house the elderly user can contact the caregiver at any time to request assistance. This communication technology would also help to reduce false alarms that are monitored from a distance by caregivers that may be unfamiliar with the new technology and alert systems (Sponselee et al. 2008). A good example here would be if a fall detection alarm is triggered possibly by the user accidentally dropping the smartwatch while trying to put it on. Instead of dispatching immediate assistance to the house, the caregiver could place a call through to the elderly user while they are preparing to dispatch to the home. This way, alerts could be verified and immediately responded too from a distance for all possible alerts on the caregivers end from the smart house or possibly in conjunction with health informatics technology.

The ‘Personal Contact List’ button will display a list of family and friends that can be contact in the same sequence as mentioned above by simply tapping on the desired name. In addition to making phone calls, the personal contact list also has the option to ‘Video Call contact’ for contacts the have access to video conferencing software. If the contact has video call username information, their current online/offline status will be posted both in the contact list next to the appropriate name and in the contact name screen. If no video call contact information is entered for a name the ‘Video Call contact’ button will be disabled showing up as a button with gray colored background and gray text. The hope for providing this screen-to-screen contact is to increase social contact between the elderly and their community of friends and family members.

The next main menu option that will be discussed is the ‘Lights’ feature. The option screen for the lights include ‘Auto-Lights’ and ‘Room Selection’. The auto-lights

options allow users to turn the automatic lighting system on or off. The feature uses motion sensing technology to turn on lights in a room when entering and turn them off when exiting. This feature is not only very convenient but it also saves on the utility bill. The delay for lights can also be adjusted within this interface allowing users to control how long lights will stay on after exiting the room. The ‘Room Select’ button brings up an interface that allows users more control over the lighting system in each room. Users can toggle specific lights within any room and also set the brightness using the dimmer fader. The lighting system options are also available on the smartwatch which also saves user preferences for dimmer settings.

The ‘Temperature Control’ button on the main interface calls up the thermostat options for ‘Heat Control’ and ‘AC Control’. Users can adjust temperature per room or per portion of the house (i.e. first floor/ second floor). Once the user selects a room or portion option, a display is called up with the options to toggle the heat on or off and to set the desired temperature. The controls are the same for both heat and AC control settings to keep it simple and easy to learn. If the heat is turned on the ‘AC Control’ button will be disabled and vice versa for if AC control is on. This is to prevent the error of having both temperature control units on simultaneously. The temperature control feature is a safe convenient way for elderly users to easily manage comfort settings from anywhere in the house.

Another main menu feature is the ‘Security System’. This intuitive interface gives the elderly user direct access to all available security features installed in their home. The ‘Alarm’ button calls up a display for users to simply arm or disarm the security system. If the system is currently off the user will see an unlocked padlock icon and the

black colored button with white outline and the word “Disarmed” in light colored text. If they wish to arm this system they can tap once on this button which will bring up the confirmation screen which they can select either ‘Yes’ or ‘No’. If they confirm to arm the house, the user will see the button coloration change to the recognizable blue colored button with the word “Armed” in light colored text, and the padlock icon will now be locked. The security system features also have the ability to lock and unlock any door listed in the system. This is set up in such a way that the user can select specific doors or set all doors to lock or unlock. The interface is set up the same as the alarm interface just mentioned with the exception that the words within the button are now “Locked” and “Unlocked”.

Another great feature that can be set up is the ‘Surveillance’ option. This option allows users to view display screens of any and all cameras currently active on their premises. The interface enables users to view all available cameras on multiple display screen simultaneously or select individual cameras with appropriate labels. The ‘View All’ button, as mentioned, calls up all camera views of the property on a multi-view screen display in which users can select any camera view by tapping once on the display screen to bring it up to full screen view mode. This feature provides more safety for elderly users and is also very convenient in conjunction with the ‘Door Locks’ button. If the elderly person is a good distance from the door when someone has arrived, they can simply use the front door camera view to see who it is. If it is someone they know and trust they can unlock the door to allow them access. This added security provides more peace of mind for the independent elderly users.[I particularly like this option.]

The final main menu selection is the ‘Feature List’ which gives users full access and control to all available features in the house. Not all feature lists will be the same because every elderly user’s needs are different. However some examples that might be in a common feature list would be ‘Stair Lift’, ‘Smart Bed’, and ‘Shower’. All of the physical features, such as the ones just mentioned, have manual controls that can override the smart home interfaces. This is to maintain a level of safety in case of interface command malfunctions. This also provides users with an option to have multiple input mechanisms to control these devices as the smartwatch can also be used for most features in addition to the touch screen interface. The idea here is to make the interface functionality similar to yet more intuitive than the manual controls so elderly users can recognize familiar operational designs. As mentioned above, the feature list is tailored uniquely for every elderly user’s needs. Other features such as music, automatic shades, and kitchen utilities could also be added to the feature list if elderly users choose to purchase such devices. [you have given an excellent description of the system features, user interface elements, and how system states change and their feedback.]

Smart House Feature Designs

As mentioned previously, our smart houses can be equipped with several smart features that can be controlled using the smartwatch and/or the touch screen application. We wanted to make all features optional according to elderly user needs and financial situations. With the help of family members and health caregivers, elder users can custom build their smart homes. There are many features to choose from. Some are more for luxury (i.e. music and T.V.) and others are necessary for safety and

assistance. For the purposes of this paper, we will discuss some of the main assistance and safety feature options which include a smart bed, a stair lift, and smart bathroom. All of these smart features functions are just enhanced versions of their normal counterparts found in current smart houses.

The smart bed is fitted for a queen or king-sized bed. The user can control the firmness of the mattress, the leg elevation and the overall height. The bed also has an upright seating position and a footstool to assist the elderly into the bed. Additionally, the left and right side of the bed can be controlled separately or simultaneously. The bed comes with a remote control with tactile response buttons, but if users so chooses, they can also use the touch screen interface which has the same interface as the physical remote so that users will not have to relearn the control interface. This bed is designed for both the disabled and the elderly who may have trouble getting in and out of bed and to enhance overall quality of living.

The stair lift follows the design of common stairlifts found in the homes of the disabled or elderly. It can be operated by the manual controls mounted to the armrest of the chair. The manual controls have a single power button with a bidirectional (left/right) joystick that transports users up and down stairs in the chair attached to the lift. When the joystick is in the middle position, the chair is at rest. When it is in the left position, the chair will move upstairs and the right position is for moving downstairs. All controls on the chair also have clearly marked labels to help elderly users recognize functionality. The chair has built in safety features such as a pressure sensor on the chair that will only allow chair functionality if the user is firmly in the seat. However, there is a button positioned at both the bottom and top of the stairs that will retrieve the

chair if the user is at the bottom of the stairs and the chair is at the top or vice versa. The stair lift can also be controlled by the smartwatch or the touch screen interface. The touch screen interface has the same interface design as the manual controls to avoid users having to relearn functionality controls and of course implements the same button conventions the elderly users would be familiar with.

The bathroom is designed in a way for ease of use and prevention of accidents with elders in mind. It also can be equipped with optional high tech controls including motion sensor faucets, an auto-air hand dryer, and an automatically flushing toilet. The shower includes automatic dispensers of body products like soap and shampoo and a body dryer. The shower is a zero-threshold design with the shower floor being on the same level as the bathroom floor to prevent potentially serious accidents. The specially designed floor tiles are also designed to dry quickly and prevent slipping.

Our design considers both comfort and safety for the elderly by implementing the designs mentioned above and water temperature regulation. The hot water temperature for the faucets and shower water cannot exceed 105 degrees F to prevent burns from scalding water. In addition to the hot water threshold, the shower temperature cannot be set below 75 degrees F to further prevent shock from extreme cold or hot water temperature differences. The shower also has positive drainage that sheets water away towards a trench drain positioned along the wall. This prevents slippery soapy water from building up under foot such as is common with centralized drainage systems. The auto-soap dispensers are also positioned above the trench drain to capture any accidental soap spills from collecting on the shower floor and causing accidents.

Another optional feature that will increase safety and comfort is the body dryer. This feature can be built right into the shower so that the elderly do not have to exit the shower immediately after with wet slippery feet. The physical control interface for the body dryer is mounted on the wall in the shower next to the feature. There is an air speed and temperature control setting with a single button to turn the device on and off. Both the shower and body dryer can be used with the touch screen and smartwatch interface which also saves desired preference settings for unique users.

Conclusion

In coming up with our smart home design, we considered everything we have learned this semester about HCI. Our goal was to create a smart home interface for the elderly that would be the best universal design for our target audience. We were able to address problems such as complex interface designs, lack of human-to-human interaction, and lack of independence due to unsafe living environments for the elderly. We believe we were able to create something truly unique through the use of our two primary multimodal interface designs. Our design has changed significantly since our first few iterations because we were able to return to our designs and reflect on some of the decisions we made throughout the process. This allowed us to implement necessary changes and all the new information we gained through lectures, readings, and expert review feedback, including building gerontechnology that could improve independent living for the elderly. [This iteration of design is clear and is what should happen in the design cycle. Good job.] Our smartwatch interface alone would not be very impressive, but the fact that we are able to marry it to a traditional smart home interface is what

gives our design something very special. The simplistic nature of the watch and the powerful control offered by the touch screen mobile device interface allow us to cover a significant amount of different kinds of users.

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Team Contributions

We all strived to keep the line of communication open in order to keep a consistent workflow throughout the semester. We made sure to communicate through skype on a weekly basis as a way to update each other and have a sense of accountability for staying on task. We also made use of google drives by editing documents and presentation together as a team at least once or twice a week. We would highly recommend this to students for all future projects.

Eric took over the smartwatch interface design by doing research and coming up with prototypes to discuss throughout the semester. Lydia and I also pitched some ideas during the development. Lydia also acted as an expert reviewer by offering ideas to bolster our designs according to the in class lectures and readings and with our target end user in mind.

Luke mainly developed the touchscreen interface design by doing research and developing prototypes. Eric and Lydia again pitched some great ideas to help refine the design. We all made sure to carefully walkthrough both designs to ensure consistency and compatibility.

We all worked on the physical design features of the house and helped determine the best features for the elderly.

We all edited and made comments throughout the process of writing this paper to ensure a coherent flow as well as address any possible design issues seen. Eric contributed a lot to the introduction, tech review and conclusion making the first draft for all of them. He also produced everything for the smartwatch portion of the paper with

Lydia and Luke editing and commenting as well as adding any helpful citations. Luke provided the literature review section and all the auxiliary literature citations used throughout the paper as well as helped to develop the introduction, tech review and conclusion. Luke also provided the mobile tablet interface design section with Eric and Lydia editing and commenting to help improve it. Lydia provided all citations that directly linked portions of our design to in class lectures and assigned readings. This helped to refine our design interface and features. Lydia provided a good draft of the physical smart house design features which Luke developed a bit more.