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Challenges in Developing Applications for Aging Populations

Drew Marie Williams
Marquette University

Md O. Gani
Marquette University

Ivor D. Addo
Marquette University, ivor.addo@marquette.edu

AKM Jahangir Alam Majumder
Marquette University

Chandana Tamma
Marquette University, chandana.tamma@marquette.edu

See next page for additional authors

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Authors
Drew Marie Williams, Md O. Gani, Ivor D. Addo, AKM Jahangir Alam Majumder, Chandana Tamma, Mong-Te Wang, Chih-Hung Chang, Sheikh Iqbal Ahamed, and Cheng-Chung Chu

Chapter 1
Challenges in Developing Applications for Aging Populations

Drew Marie Williams
Marquette University, USA

Md Osman Gani
Marquette University, USA

Ivor D Addo
Marquette University, USA

AKM Jahangir Alam Majumder
Marquette University, USA

Chandana P Tamma
Marquette University, USA

Mong-Te Wang
Tunghai University, Taiwan

Chih-Hung Chang
Hsiuping University of Science and Technology, Taiwan

Sheikh Iqbal Ahamed
Marquette University, USA

Cheng-Chung Chu
Tunghai University, Taiwan

ABSTRACT

Elderly individuals can greatly benefit from the use of computer applications, which can assist in monitoring health conditions, staying in contact with friends and family, and even learning new things. However, developing accessible applications for an elderly user can be a daunting task for developers. Since the advent of the personal computer, the benefits and challenges of developing applications for older adults have been a hot topic of discussion. In this chapter, the authors discuss the various challenges developers who wish to create applications for the elderly computer user face, including age-related impairments, generational differences in computer use, and the hardware constraints mobile devices pose for application developers. Although these challenges are concerning, each can be overcome after being properly identified.

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INTRODUCTION

An aging population presents several challenges in ensuring that our infrastructure can support the needs of elderly people, enabling them to live healthy, independent, and productive lives. According to the United Nations Population Division statistics, at the end of 2009, the elderly population reached 737 million, accounting for 10.8% of the total worldwide population. In the year 2025, it is projected that the elderly population will account for 15% of the total population (Majumder, Rahman, Zerin, Ebel, & Ahamed, 2013a; United Nations, n.d.). As the elderly population increases and people continue to live longer, more people will require help with various aspects of daily living and disease management. Doctors and caretakers may need to monitor the wellbeing of more elderly individuals, while keeping the costs of enacting such monitoring low. Elderly individuals, who may be suffering from aging-induced ailments, may also take measures to remain active and social.

These are all concerns that computer applications can assist with. Applications like email, video telephony, web browsers and reminder management services are able to support and enrich the daily lives of older adults. However, often these applications can be difficult to use for the elderly individual. In general, when developers are creating usable applications for the elderly they need to consider three main types of challenges: sensory-based challenges, challenges arising from cognitive decline, and generational differences. Mobile application developers need to consider these challenges as well as additional mobile specific challenges, such as interface constraints and the size of the device.

Aging is often accompanied by a decline in sensory abilities. Vision loss is relatively common in most older populations, afflicting individuals who are over the age of 60 more prominently (Phiriyapokanon, 2011). In addition, roughly 30% of adults over the age of 65 (Mahncke et al., 2006) have some form of hearing loss, which can interfere with face-to-face communication and make using the telephone more difficult. Vision and hearing loss attract the most attention, but one's sense of smell and taste diminish with age as well. In addition, sensory decline is not consistent across the elderly population; some users may experience no significant decline in one sense, and others may experience an impairment of multiple senses, which can be an especially challenging scenario.

Cognitive and motor skills can also decline with older age. Cognitive decline may also afflict elderly individuals in varying ways; older patients with cognitive impairment can develop difficulties in remembering and correctly adhering to instructions, causing activities such as cooking and driving to become dangerous. Elderly individuals may also find that older age and accompanying illnesses (such as arthritis) can impair their motor abilities, making precise movements painful and more difficult (Nunes, Silva, & Abrantes, 2010).

Elderly users also may have less experience with or fear using computers, which can affect how they expect a computer to work, or what sorts of expectations they have regarding computer use. Elderly users may also take longer to perform certain activities, and to read instructions and textual information (Coyne & Nielsen, 2001; Nielsen, 2013). They also can be reluctant to do something they think will cause system failure. Introductory classes may also help reduce fear of using computers (Morris, 1992), but unfortunately many retirement homes provide very limited or no access to personal computers.

Mobile computing devices offer additional opportunities for the elderly adult user, who may look to using mobile devices to track activity and health parameters on-the-go. In fact, it has also been projected that by the year 2014, public and private healthcare providers could save between $1.96 billion and $5.83 billion in healthcare costs worldwide by utilizing mobile health application technologies for health monitoring (Majumder, Zerin, Uddin, Ahamed, & Smith, 2013b). However, designing for the small form factor of mobile devices can be a challenge; users with poor vision may not be able to see the screen of a smart phone as easily (Motti, Vigouroux, & Gorce, 2013). In addition, many mobile applications utilize "intuitive" motions in their menus and screens, which may not be immediately understood by the less-experienced elderly user, or able to be performed with the speed and accuracy required.

The good news is that one can find solutions for these challenges once they have been properly identified. Application designers can consider the impact of age on usability and include large font, clear buttons, and high-contrast text. The use of tutorials for different application screens can assist the elderly individual in remembering how to perform functions in-application. These tutorials, coupled with increasingly involving elderly individuals in the development process, can also help with minimizing concerns about using applications that result from generational differences. Even a problem such as the small form factor of mobile devices can be easily countered by proper design and user testing. In short, highlighting these challenges in developing for the elderly user – sensory cognitive impairments, generational differences, and the new constraints of the mobile devices - help developers create more effective desktop and mobile-based applications.

Motivation

As mentioned before, computer applications hold great potential in helping elderly adults track their own wellness, and promote active aging. A usable desktop or mobile application can improve the independent living of elderly users with current mobile technology, which allows developers to do everything from tracking daily exercise and activity patterns of the older adult user, to predicting the occurrence of falls in older adults. However, in addition to these uses, computer applications also provide elderly users with methods of communicating with friends, keeping up with current events, working from home and accessing educational opportunities – all from the comfort of their own home.

As examples of how the elderly are prevented from taking advantage of possible benefits of desktop and mobile applications, consider the following two scenarios:

Phase One: Elise is 82 years old, and enjoys reading stories. However, lately her eyes have been troubling her, and it's more difficult to see the text of her paperback novels. There are a variety of e-reader applications for mobile computers and desktop computers, which offer features such as color inversion (putting white text on a black background) and text enlarging features to help users read their contents better. However, when she tries to find these features, Elise has difficulty understanding where they would be in the application, and thus shies away from using these programs.

Phase Two: Bob is a 60 year-old who has been suffering from a gait pattern abnormality, which has led him to suffer 3 major falls over the last year due to unbalanced walking. Bob is psychologically traumatized by the consequences of these falls, and prefers to sit at home. Current mobile technology allows detection of an unbalanced gait using the accelerometers of small, mobile devices – such as the smartphone that Bob owns. However, the applications available for Bob to use are so complicated that he prefers not to bother himself with them.

Properly-designed applications can not only assist with health management and overcoming age-related impairments, but provide entertainment, educational and work opportunities.

BACKGROUND

Since the introduction of the personal computer, the user interface has gone through considerable changes, evolving from one that was primarily text-based to a modern graphic-intensive view. However, no matter the style of computer interface currently in use, the idea of making computer interfaces more accessible for users has always been a hot topic. Critics of the software development industry point out that often, technology appears to be designed with only the abilities of the designer in mind (Stewart, 1992). Despite this, computers (if designed properly) hold great promise for the elderly user.

The following sections focus on two main ideas: research in addressing challenges elderly users face while using computers, and progress in development towards having a series of standards for accessible computing. Accessibility, admittedly, is a concern that covers a larger population than just the elderly; however, many of the steps taken to make computers more accessible have also helped elderly users. Developing a series of accessibility standards, that would direct application developers towards requirements and guidelines for developing applications that all can use, would certainly impact the ability of the elderly user to use applications.

Computers and the Elderly: A Brief History

Early literature found that the elderly individual was "surprisingly receptive" to using computers, with many elderly individuals taking advantage of the software available at the time (Ruby, 1984). The potential for computers to enable elderly users to live independently, stay in contact with friends, mitigate problems associated with aging and receive more timely medical care was quickly identified (Elton, 1988). However, while elderly computer users in the 1980s showed interest in learning how to use computers, complaints about blurry graphics and difficult keyboard input indicated that new user interfaces specifically for the older adult computer user would assist in making computers more attractive for elderly users (Tobias, 1987). Solutions to many of these early problems were developed, including computers with special qualities built in to reduce eyestrain via larger displays and keyboard buttons (Ruby, 1984). Vanderheiden (1987) discussed a number of accessibility-related problems computers in 1987 faced, and gave appropriate guidelines and suggestions for accessibility related to computer input, output, controls, media, and documentation. While the focus in this work was not explicitly the elderly population, concerns were raised that affect elderly users – such as problems incurred when using audio tones only in alerting the user of new information. It was also noted that more research on how to design menus and screens for the abilities of the elderly user would be beneficial (Tobias, 1987).

As computers became more popular, more attention was devoted to creating elderly-friendly applications. By the 90s, a variety of software was actively being used by elderly adults; however, barriers to computer adoption were still noted (Ogozalek, 1991). More specific research was also conducted related to how best to design computer programs for the elderly user. For example, it's understood that visual impairments brought about by old age mean that font size, text and screen color contrast play roles in how elderly users interact with applications. Hawthorn (1998b) noted, however, that allowing a user to change settings regarding the display of font and screen colors often relied on a user's visual abilities. Age-related cognitive decline was also noted as being important in designing applications, as developers needed to take into consideration cognitive load related to using an application (and reduce this load where necessary) (Hawthorn, 1998a). Finally, studies were also conducted to survey elderly users about the particular interfaces they preferred: Ogozalek (1994) discovered that elderly users, especially women, preferred a multimedia interface to a text-based information for a task like learning about new prescriptions. Anderson et al. (1999) also found that elderly users perceived speech-based interfaces to be quicker and easier than typing, although in reality there was no difference in results between the two.

By the year 2000, research was increasingly being poured into communication and observation of elderly users in order to derive proper interface requirements for computers. Using focus groups and coaching to investigate how elderly users interacted with computers also became more popular. In one study in coaching older adults in how to use computers, Kantner (2003) found that fear of making a mistake was a more frequent problem for older adult users than any visual or typing difficulties. An ethnographic study of elderly computer users also pointed to a strong reliance on notes to keep track of jargon and steps in how to work with applications (Sayago, Sloan, & Blat, 2011). In response to findings related to elderly users' abilities and computer interfaces, researchers worked to adapt existing interfaces for the needs of elderly users; one example from the University of Dundee, Scotland (Newell, 2004) included the development of a web browser with minimal functionality and font, contrast, and button size rations that were found appropriate for older adults to use. However, applications such as this quickly raised another issue: elderly adults don't necessarily wish to use "elderly-friendly" applications (Durick, Robertson, Brereton, Vetere, & Nansen, 2013; Sayago, Sloan, & Blat, 2011).

In more recent years, new approaches to developing accessible interfaces have grown in popularity, including the advent of adaptive interfaces and affective computing. The former concerns interfaces that log a users' interactions with a computer and provide appropriate interface changes as a result of analyzing these logs. Popular examples of this are SUPPLE and SUPPLE++, which are interfaces that enlarge and rearrange elements onscreen for users with different motor impairments (Gajos, Wobbrock, & Weld, 2008). Affective computing uses emotional response to tailor a computing experience for a user – this could potentially be used to pick up on emotional cues, such as frustration, and present the user with help screens as a result. Mobile devices also have become more popular, and often utilize touchscreens for input in lieu of buttons. For this reason, an elderly individual can find mobile devices easier to use in some applications, as touchscreens can be friendlier to the needs of the elderly adult. However, the smaller screen size means that applications must make decisions about the sort of information displayed to the user – and as a result, some forego help screens, tutorials, and other assistance, opting to make assumptions about what the user already knows. One study pointed out that there existed a variety of age-related differences in how elderly users interacted with icons used in mobile applications, and that these differences could be overcome simply by improving characteristics of the icons (Leung, McGrenere, & Graf, 2011).

Working towards Accessible Standards

Research in developing accessible interfaces has ultimately led to the development of guidelines for developing accessible interfaces. However, said guidelines are numerous and often fragmented across platforms/devices and countries. There do exist international standards, created by the International Organization for Standardization, an independent developer of voluntary international standards (International Organization for Standardization, n.d.). However, these are voluntary and do not need to be followed. Of these standards, ISO 9241-171:2008 (International Organization for Standardization, 2008) provides the most specification for accessible software for people with a wide range of abilities, including those who may only be temporarily disabled and elderly users. Other standards produced by the ISO offer standards for providing accessible software via popular development languages, such as

Java (International Organization for Standardization, 2014), and when developing for different operating systems, such as Linux (International Organization for Standardization, n.d.). Standards related to newer interface components, such as natural language dialogues and voice interaction, have been proposed (Hodgkinson, 2008).

Other location-specific laws require thinking about accessibility for some or all programs. In the United States, Section 508 of the Rehabilitation Act of 1973 requires that federal government technology is accessible for all computer users, including elderly users (US Government, n.d.). European Mandate M 376 will set a series of regulations requiring base accessibility functionalities for technology; technology affected by this mandate will range from hardware, to software and web content (Martínez & Pluke, 2014).

Some software companies have taken the act of creating accessible software into their own hands. IBM, for instance, publishes an accessibility checklist with guidelines that include providing options to display visual information related to all audio cues, dissuading the use of animation that operates beyond a certain blink frequency, and inheriting existing operating system conditions related to visuals (font size, color, etc) (IBM, 2009). Microsoft provides users of Microsoft Windows access to contrast and color options, in addition to accessibility enhancements such as ClickLock (Microsoft, n.d.). Likewise, Apple has features in place in the Macintosh OS in addition to their mobile operating system, iOS, which seek to aid computer users with different abilities (Apple, n.d.). Finally, the Android mobile operating system also provides a number of suggestions for maintaining an accessible mobile application (Android Open Source Project, n.d.).

Despite having fractured suggestions about how to deal with developing accessible computers, there is at this time a good idea of the different abilities that elderly users have, and the different challenges modern computers pose to the elderly computer user.

CHALLENGES IN DEVELOPING APPLICATIONS FOR ELDERLY ADULTS

As mentioned, older adult users can have a wide variance in physical and cognitive abilities, due to both age-related impairments and various chronic illnesses (D. Williams, Ul Alam, Ahamed, & Chu, 2013). Older users can also experience differing familiarity with computers, and can be influenced by social expectations regarding people of their age groups and technology (Durick et al., 2013). These barriers can affect how they react to applications for both desktop computers, and the growing number of mobile applications. Understanding the capabilities and limitations of older users will help researchers, designers, and developers create usable applications for elderly computer users (Niamh Caprani & Gurrin, 2012).

Sensory Challenges

As individuals grow older, various physical impairments may become apparent. Elderly adults may experience a decline in vision; this can manifest as presbyopia, a loss of peripheral vision, declining dark adaptation abilities and lowered recognition of color contrast (Nunes et al., 2010; Phiriyapokanon, 2011). Poorly sized and colored components (labels and buttons) of applications can be very frustrating to view. Elderly individuals have also been shown to experience difficulty hearing higher pitched sounds, and also separating particular sounds from noise. Sometimes, a developer may not get the attention of a user via visual prompts, so proper use of audio is a must in accessible applications. People may also experience reduced sensations; a certain amount of stimulation is required for elderly users to sense vibration. Users may experience reduced dexterity and motor control, making precise mouse control, accurate movement, and clicking or tapping small targets on the applications very difficult (W3C Web Accessibility Initiative, n.d.) Ailments common in older age, such as arthritis and swollen fingers, can limit a user's ability to communicate with the computer using a mouse or a keyboard (Nunes et al., 2010). A growing number of applications for desktop and mobile computers alike offer numerous multi-finger gestures for new touchscreen interfaces. Those with upper limb and mobility problem face difficulties in performing different gestures like touch or click buttons, and controlling sliding functionalities.

However, of the varying age-related impairments an elderly user may suffer from, one of the most important things to remember is that one ailment may not affect the older adult user as much as it may affect their peers due to different habits in their younger age (Durick et al., 2013). The abilities of the individual elderly user vary greatly; age-related impairments vary across the entire elderly population.

Cognitive Challenges

In addition to sensory decline, elderly adults often undergo a degree of cognitive decline. In short, this often manifests as short-term memory loss, becoming more easily distracted, and declines in analytical power, communication power, and reading skill. Elderly users may also experience difficulties in understanding compound and large amounts of text, and following long and complicated instructions. If a great deal of irrelevant information is displayed in an application's interface, a user has a higher chance of getting lost while navigating the application.

As a result of decline in cognitive functions, elderly computer users may not be able to parse large amounts of information in the same manner they used to, or multi-task between two different applications efficiently (Williams et al., 2013). Using multiple windows or pop-up messages can cause more problems; while useful in conveying information for younger adults, such things can often make older adults feel lost in an application. Likewise, elderly computer users often become confused and feel helpless when they encounter error messages. This confusion and helplessness can affect their confidence in using applications, and limit their ability to use different devices.

Generational Challenges

Not all challenges that an elderly user may face are the result of a physical, age-related impairment. The differences between generations can also pose unique challenges for the elderly computer user; elderly computer users often find that they have less experience with modern technology than others. Lack of experience with particular application interfaces and icons can make the meanings of the icons more difficult to interpret (Leung et al., 2011). Help screens and tutorials can be laden with jargon unfamiliar to the elderly adult user; even in one-on-one tutorial sessions, coaches often need to adjust their language for elderly computer users (Kantner & Rosenbaum, 2003). Additionally, expectations regarding computer use may be different as a result of having less experience with computers – elderly users can be more fearful regarding internet communities, storing their personal information online or in applications, and things of that nature (Sayago, Sloan, & Blat, 2011). Hearing stories about the dangers of shopping online or regarding the latest hacking incidents via the news can alter the users' perception of the safety of technology, and create barriers to proper technology acceptance. However, even for those elderly users with some technological experience, the current pace at which technology is moving is so rapid that users often can find themselves having trouble keeping up with modern computing trends.

Mobile Device Challenges

In some respects, mobile devices bring resources that developers can use to overcome challenges faced when developing desktop applications. For example, touchscreens are prominently used in mobile devices, which are often recommended over keyboard and mouse interfaces for the older adult user (Motti et al., 2013). However, with mobile devices also come new challenges: mobile devices have a decidedly small form factor, and users with poor vision may not be able to see the screen of a smart phone as easily. In addition, users can experience difficulty when using the touchscreens of mobile devices due to the small size of the targets (icon, button, and menu), and face difficulty handling a stylus to control and interact with the device (Holzinger, 2002; Norman, Kemper, & Kynette, 1992).

Experience with mobile devices may affect how applications are understood and the speed with which they could be used. A lot of mobile applications advertise having usable and intuitive interfaces, which are easy to pick up for all users. However, much of the ‘intuition’ required to interact with these interfaces is actually learned over time by interacting with other mobile applications. When developers remove help screens due to belief that their application is “intuitive”, they can make it much more difficult to use for the elderly individual; not only because of the elderly users’ inexperience with mobile device applications but also because of the existing correlation between increasing age and decreasing desire to use trial-and-error to figure out how to use an application. Leung et al. (2011) suggests that elderly people prefer to use a mobile device’s manual (if available) and learn step-by-step instructions for how to complete a task.

Finally, elderly adults are often very private when it comes to using the internet. In the world of mobile applications, many mobile applications have strong ties to the internet and offsite data storage (Sayago, Sloan, & Blat, 2011). In fact, many mobile applications have corresponding web applications – something that is not necessarily true with desktop applications. As a result, users may be more wary regarding storing their data in “the cloud” or just in internet databases. Developing a notion of trust between the user and the application is certainly one of the more difficult design challenges facing mobile developers.

ADDRESSING CHALLENGES IN APP DEVELOPMENT FOR OLDER ADULTS

With modern advances in user interface design, one can now address individual sensory problems of elderly users *and* the problem of developing for a varied user base of elderly adults. Adaptive user interfaces (Fink, Kobsa, & Nill, 1997) can assist older adults by asking the interface of a particular application to adapt to the user’s abilities and expectations. Affective computing (Tao & Tan, 2005) can determine the current emotional state of the user, allowing the program to decide if the user may need help in navigating through complex menus and cognitively-challenging screens. Closely involving elderly users in the development and design of software can aid developers in understanding how best to design applications that fit their needs (Valentine, Bobrowicz, Coleman, & Gibson, 2011). Finally, utilizing secondary displays available to the developer, such as haptic displays, can help in making up for the small form factor of mobile devices (Nishino, Fukakusa, Hatano, Kagawa, & Utsumiya, 2012).

Addressing Sensory Impairments in Application Design

Addressing sensory impairments in application design requires developers to create an application usable by computer users with differing sensory abilities, and give users the ability to adjust the application to accommodate for their particular needs. In terms of developing for declining vision, fonts should be bold and large, and well contrasted against their background. Proper color tone makes the content more visible. Images should be directly relevant to other material on screen to avoid confusing the user. Animations, if used, should also be designed so that they do not overwhelm the user; IBM recommends a blink rate between 2-5hz in their software guidelines (IBM, 2009).

Audio should be tweaked to accommodate sensory impairments as well (if used) – an audio alert should be styled to not alarm the user too unnecessarily, but grab attention. The pitch should be within the hearable range for the elderly computer user, which changes as an individual ages (Phiriyapokanon, 2011). Visual alerts should be accompanied by these appropriate audio prompts, to make the application's alerts accessible for users who have poor vision but good hearing. Additionally, if an application relies on a lot of audio, it's a good idea to provide subtitles for those users who have poor hearing; this is in fact required for U.S. government software (IBM, 2009).

For those with motor impairments, developers should take care to support as many different input devices in their applications as they can. This includes supporting the mouse and keyboard, touchscreens, pen tablets, and other sorts of input. New, gestural-based input devices may also be useful in navigating menus in the future for elderly users. Utilizing voice control methods of navigation and input can be helpful for the people with physical impairments, although these need to prompt and guide the users appropriately.

A common way to overcome the challenges listed here is to simplify an application and label it as being for the elderly user as it designs for the existence of *all* of these age-related impairments existing to the same degree in elderly users. However, this approach can often backfire; as mentioned, elderly users often shy away from applications being stated to be *for* the elderly user (Durick et al., 2013; Sayago, Sloan, & Blat, 2011). Integrating adaptive interfaces, which adapt to the abilities of the user instead of asking a user to adapt to it, can solve this problem. Adaptive interfaces seek to make assumptions about the user of a program, and adapt to expectations resulting from those assumptions. Monitoring the users' interactions with the program, or simply asking the user questions about their abilities could compile these assumptions. The SUPPLE and SUPPLE++ projects from Harvard University are fantastic examples of what adaptive interfaces can do: here, the interface either monitors use of the application, or asks the user a series of questions about their abilities, before changing relative to the users' responses (Gajos et al., 2008).

Adaptive interfaces in practice might ask a user to take a survey where they answer questions about their vision, hearing, and motor skills – depending on the answers to those questions, the interface of the application being developed could change. The application could then augment these changes by watching a user's interactions with the application itself, building a profile over time related to the user's actions, and further adapting the interface based on this. This would help ensure that an application's interface worked with a particular elderly computer user's abilities, without oversimplifying anything for a different user. In fact, utilizing sensors available to the program, one might even take this approach another step further and monitor for behaviors such as squinting or lack of response to audio via computer cameras, and perform actions such as enlarging text or increasing volume in response.

Addressing Cognitive Challenges in Application Design

As mentioned earlier, not all elderly individuals experience the same degree of cognitive decline. Even those with a relatively high degree of cognitive decline may have enough experience and knowledge gathered over the years to offset any decline they may experience (Liao & Fu, 2014). While complex screens of information may confuse some users, other users may be able to take such screens in stride. The act of over-simplifying an application can be just as problematic as over-complicating an interface.

The key in developing an interface for the cognitive abilities of the older adult user is to keep interface layout and navigation clear and straightforward. The application components and the interfaces need to be self-describing, and unambiguous. Screens should not require too much multitasking; if a screen requires a user to read instructions while several pop-ups alert the user to issues in the background, an elderly user may get confused. Finally, jargon the user is not familiar with should be avoided, and when it is required, defining it and making sure that it is used consistently can actually help an elderly user learn terms used.

However, the focus then shifts to two concerns. For one, an elderly computer user experienced with computers may find a vastly simplified interface to be inappropriate for their needs. In this case, utilizing ideas similar to our ability-adaptive interface from before would be beneficial for ensuring accessibility without compromise. Developing a system where, depending on cognitive ability, more or less information is displayed for the user would help users with advanced cognitive impairment parse the information available to them onscreen, while giving. Using a system similar to this, where the amount of text and content onscreen changes depending on a level of cognitive ability, would assist in ensuring screens do not overwhelm elderly computer users.

Additionally, even if a developer takes great pains in laying out content within an application in a clear and understandable manner, and developing a hierarchical system of content, he or she may still succeed in confusing an elderly adult computer user. For this reason, a strong set of tutorials for users, that explain the proper methods of using the application, can be extremely helpful. Previously, it has been shown that the elderly have been shown to prefer using step-by-step guides in lieu of trying things out for themselves (Leung et al., 2012). Creating tutorials for the elderly computer user caters to their desire for a manual or a guide to an application.

Developers have created help guides and tutorials in the past with varying results. With affective computing, developers can now seek out computer users who are demonstrating particular emotions – such as frustration, sadness, or confusion – and give these users in particular the help they may need, instead of assuming that all users of a particular application will need help. After all, the existence of emotions like these can hamper learning (Sarrafzadeh, Alexander, Dadgostar, Fan, & Bigdeli, 2008), so it's useful to detect them before a user gets frustrated with a device, and gives up on learning how to use it. While emotion detection can take place using a camera and facial recognition, pressure-sensitive mice and keyboards (Hernandez, Paredes, Roseway, & Czerwinski, 2014) in addition to gaze tracking (D'Mello, Olney, Williams, & Hays, 2012) can be used to pick up on stress and engagement levels. This can be helpful in determining whether a user is becoming distressed by an application, and thus is in need of assistance.

Addressing Generational Challenges in Application Design

Elderly users often have different ideas about technology and how it should be used. For example, an elderly user, having grown up without using computer applications, can have difficulty seeing how a computer can benefit them. This in turn can affect their desire to try and learn how to use an application, or a computer – the work involved in learning does not adequately offset the benefit the application may deliver (Durick et al., 2013). Thus, the developer should make it clear that the user will greatly benefit from interacting with the application. Some insight into how to do this might be gathered by understanding how older adults learn to use mobile devices in particular (Leung et al., 2012), or via adapting to generation-specific knowledge of the older adult user to enhance the usability of the application (Liu & Joines, 2012).

Elderly computer users may also have strong concerns related to the security and privacy of applications – often opting out of sharing details of their life publicly (Sayago, Sloan, & Blat, 2011). This means that applications that collect large amounts of data, share information about the user, or save data to the cloud, can be problematic for elderly adults to trust. The aforementioned adaptive interfaces and affective computing-utilizing tutorials would be good examples of such applications. In these cases, the developer needs to ensure that the elderly computer user can trust their application.

Intuitive designs and gestures should also be checked with users, to ensure that they actually are intuitive – sometimes the 'intuition' required to operate an application relies on a user having previously used a similar application and remembering functionality of that application. The best way to ensure an application's features are 'intuitive' or helpful for an elderly user is to sit with a user and ask them for input on the application's design. Developers have the tendency to overestimate the knowledge a user has of technology (Newell, 2004).

Addressing Mobile Challenges in Application Design

The rise in popularity of mobile computing devices indicates that it is important to look into enhancing the usability of mobile applications, given the challenges that developers face when making mobile applications. Dealing with smaller screens means smaller text and smaller spaces in which a user can tap a button. It has been shown that reducing the size of a target for selection results in difficulty in selecting the right target, increased task completion time, and increased cognitive pressure (Fezzani, Albinet, Thon, & Marquie, 2010) – all of which can dissuade the user from using an application.

However, here multimodal interfaces can be used to bring further clarity to applications. Touchscreens that give haptic feedback – that is, touch-based feedback – can be useful for older adults using a smartphone. Elderly adults will be used to the feedback that buttons, such as those found on a keyboard, give the user. For this reason, the flat surface of a touchscreen may be awkward to use to type or interact with. However, touchscreens that give vibratory patterns that mimic buttons being touched have been shown to be helpful for users less experienced with computers (Nishino et al., 2012).

Applications designed for mobile devices are some of those most likely to suffer from issues related to how 'intuitive' the design is. This is because the smaller form factor means that new methods of interacting with the interface, such as gestures, and new methods of displaying information onscreen are required to create good interfaces. However, without proper explanation, gesture-based controls (such as the aforementioned pinch zoom) can remain hidden from the elderly adult computer user. Likewise, design elements that commonly display information for a user, such as icons, can instead obscure information when used in lieu of words to save screen space. Icons in mobile applications can be difficult to understand for a novice user, even if the meaning of the icon is semantically close to its appearance. Therefore, these are the places where within a mobile application where tutorials would be welcomed by a user. Since mobile applications are often much simpler in function when compared to their desktop companions, developers may only need to write a quick introductory tutorial for an application. This of course, isn't always the case, and should be evaluated on a case-by-case basis.

Now finally, elderly users who have recently become familiar with using a computer may not immediately be thrilled that they now have to learn how to use a mobile device as well. Mobile application developers in particular need to make sure their audience is aware of the benefits of their application, so that elderly users may consider purchasing a mobile device to run the application on. However, one prominent design challenge is to identify the best means to convey the advantage of an application to an elderly computer user. Insight into how to best accomplish this might be gathered through a thorough understanding on how older adults learn to use mobile devices (Leung et al., 2012).

Developer Policies and Strategies

Not all of the guidelines outlined here will be applicable for all applications. If the application is simple, creating advanced algorithms, such as those designed to detect emotion and display tutorials for the user relation to the emotions detected, may only result in adding complexity and development time to the project. This being said, the development team always needs to make effort to understand the needs and requirements of the elderly population in particular that they are designing their application for, and create a plan accordingly for how to approach the application design.

In all cases, developers should interact with their target customer base before beginning development. Otherwise, one may pour money and effort into developing features – such as social networking abilities, or cloud storage – that the elderly individual won't use in the end! Interacting with a variety of elderly individuals in your targeted audience (be it consumers who shop at a particular store, or folks interested in news in a given are) will help clarify what sorts of features an application should offer. In one study where some developers had access to stories about the lives of elderly users and their access to technology and others did not, five of the six teams with access to user stories utilized them in developing their application, and the group without access to the stories wished they had access (Valentine et al., 2011). Understanding the background of your target audience is crucial in developing something that they like, and will actually use.

Checking progress with the customer during development is another tactic that can assist developers in creating properly-designed applications. One popular strategy for bringing the customer's opinion into the development process is using an agile development methodology. Among other things, agile development prioritizes collaboration with the customer (often face-to-face) and frequently changing requirements (Paulk, 2002), both of which are useful when developing for the needs of the elderly individual. Agile can help with keeping application development on track, determining if an application needs new requirements for additional accessibility features, and integrating said new requirements. As agile development is frequently used in software development, often implementing this methodology won't require much additional training (as developers may be used to it already), but even if training is required, a multitude of agile development resources exist – so time and effort spent making training materials for a customized solution is not necessary.

Now, since no one policy exists for developing applications for the elderly adult, if the developers expect to make a number of apps which should be usable by elderly individuals, particular policies for their target market might be developed after discussions with their customer base (or an existing policy may be adopted). Having a particular policy for developing applications for elderly individuals can help accelerate workflow and make development of accessible applications an easier process. Any policies enacted should hold for all applications created, unless the application is targeted at a very specific age group (such as some educational applications for children may be). Even tools that one thinks the average elderly adult may not use, might be interesting to some! In addition, since no concrete required guidelines exist, any policy enacted can be adapted as new technology (such as wearable devices) becomes popular, or if the mindset of elderly individuals towards technology changes. However, always keep in mind that having an interface that adapts is much better than having a series of guidelines that are deemed acceptable for all elderly individuals.

FUTURE RESEARCH DIRECTIONS

As one would expect, the manifestation of Amdahl's law (Rodgers, 1985) in today's age continues to spark hardware and, consequently, software innovations across multiple devices and platforms. As wearable computing devices find their way into our everyday lives, there exists an inherent focus on user interface usability best practices which will do no less than enhance the promise of more usable devices for elderly users. These devices use natural user interfaces (NUI) and spoken language understanding (SLU) capabilities that make it possible for elderly users to verbalize a few voice commands to the wearable device in lieu of typing on, perhaps, a small keypad.

Loureiro (2011) noted that more natural ways of interacting with computers could be involve gesture recognition, speech and handwriting. Natural user interfaces (NUI) like the Microsoft Kinect for Windows sensor, create new ways to interact with machines through gestures, sound, facial expressions, and many more. There are many advances into fusing augmented reality with NUI to create new ways of interacting with machines. The promise of these new interfaces present opportunities for life-saving and assistive tools.

While bewildered thoughts, dementia and other contests associated with old age are not uncommon among elderly people, the new wave of technologies stand the chance of assisting elderly people to overcome a good number of these trials. For example, a smart-shoe (wearable device) coupled with a smartphone can be used to track an elderly person's gait, predict a fall and resultantly assist the human to correct the ensuing mobility imbalance before the fall happens. McNaney et al. (2006) posit that their 5-day field trial study regarding the acceptability of Google Glass as a viable assistive device for people with Parkinson's yielded positive results.

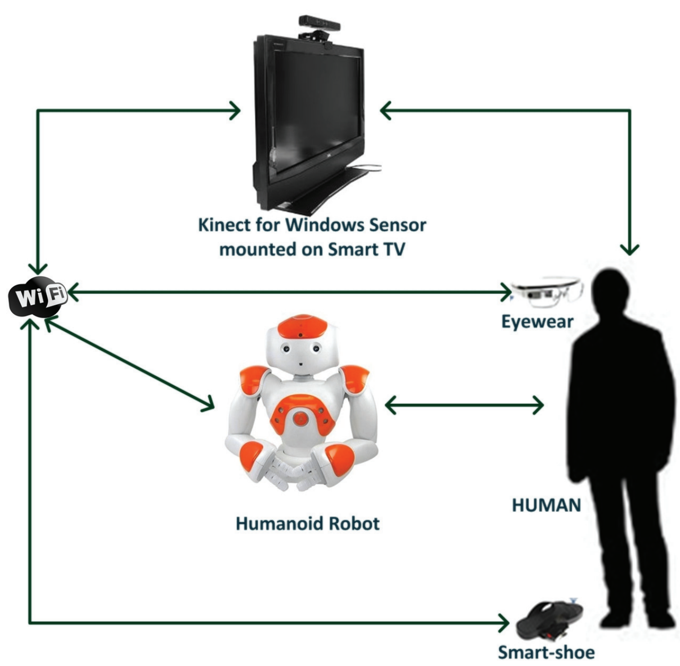
Researchers are also working on the interesting undertaking of leveraging communication robots as a means to provide elderly people with companionship in the future. Broekens (2009) posits that assistive social robots are sometimes designed as a digital technology interface for the elderly. Personal robots are also poised to be heavily favored in elderly care scenarios in the near future. Sociable companion robots can be leveraged to provide personalized mediation to elderly citizens with dementia. For example, the robot can recall a previous event from its centralized knowledgebase and candidly help the elderly person recollect an event that he or she might have lost memory of. In a real-world deployment and field study of a conversation robot working in an elderly care environment, Sabelli (2011) found that having a robot that can move closer to the elderly people (who often have limited mobility) is a well sought after feature. In addition, the team discovered that the elderly have different expectations of the robot and they tend to interact with the robot a little bit differently than how non-elderly people might interact with it.

Case Study: Elderly Person in a Futuristic Smart Environment

As an example, one can consider an elderly person, Jimmy Burns, who lives in a futuristic smart environment consisting of the following elements:

- **3D Smart TV with a Microsoft Kinect for Windows NUI Sensor:** Jimmy is able to select various channels and navigate through the television (TV) channel guide by using the NUI interface, as he waves his hands in the air to interact with the 3D TV guide. Jimmy is also able to change channels on the entertainment device through voice commands. Based on Jimmy's detected emotional state and preferences, the entrainment options available are tailored to put the human in a better mood. As a result, a critical concern of the elderly human will dwell on the implementation of adequate privacy measures in an always-on solution that is capable of eaves-dropping on various conversations and amassing massive data regarding the user's behavior patterns. The Kinect for Windows device is also used to present a computer gameplay activity to help motivate Jimmy through cognitive stimulation and also invite him to interact with new technologies.
- **A Sociable Humanoid Robot:** The robot is able to provide a person suffering from dementia with tips and clues for recalling past events and knowledge. In achieving this goal, the humanoid robot will need to be able to coexist in the same environment as the elderly person while providing companionship and helping with physical chores in the smart home. Tanie (1999) posits that in a scenario of this nature, the robot will need to be able to gain the confidence of the elderly person by exhibiting friendliness and safety (see Figure 1).

Figure 1. An illustration of an elderly person interacting with a futuristic smart environment



- **A Smart-Shoe:** Jimmy is able to walk around the house while wearing a smart shoe. Knowing that at Jimmy's age he is likely to fall occasionally, the smart-shoe is able to detect complex activities and assist Jimmy with fall prevention capabilities. The assistive alerts that the system provides when it detects a high probability for falling, takes into consideration Jimmy's need for hearing aids. Alternate solutions will need to be sort to notify Jimmy to correct his posture before he is likely to fall.
- **Smart Eyewear:** Jimmy wears a Google Glass device almost everywhere in the smart home. The Google Glass supports the smart shoe wearable device in predicting a fall. In addition, the eyewear allows Jimmy to recall previous knowledge recorded by the robot, the Kinect sensor or the eyewear.

All the networked devices in this case study will need to be able to communicate securely through the private wireless network. To support the massive amount of data needed to provide recall capabilities, a cloud hosted model is considered. More importantly, natural user interfaces and natural language processing techniques are leveraged to allow Jimmy to interact with the environment naturally and intuitively.

CONCLUSION

Aging remains an inevitable experience. With aging may come decreased eye sight, auditory impairments, susceptibility to frequent falls and other motor control challenges, and various cognitive and health issues (Loureiro, 2011). A combination of these and other conditions make it a worthwhile challenge for application designers to carefully consider critical factors that go into making a given application usable or accessible to elderly citizens.

While futuristic devices and gadgets offer more appealing platforms for building NUI applications for the elderly, concerns surrounding privacy, physical security and the safety of these systems are still of great concern for the elderly generation. Depending on the form factor at hand, application designers might need to optimize the user experience in a way that supports humans with limited vision capabilities. Multi-touch and gesture-based interaction devices offer an enticing opportunity for improving the usability of applications for the elderly generation (Haikio, 2007, Loureiro, 2011). Even so, while the likes of Apple's Siri and Google's Glass devices are capable of listening for specific voice commands in spoken language, a more usable voice-driven interface for the elderly citizens should expose support for natural spoken language understanding across various platforms that may be engaged in the elderly person's interaction space.

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KEY TERMS AND DEFINITIONS

Accessible Software: Software designed for use by individuals with a wide range of different abilities. This can include software for people with visual and hearing impairments, and software designed for elderly individuals.

Adaptive Interfaces: Interfaces that, instead of requiring a user to conform to their nuances, change in relation to the abilities of the user.

Affective Computing: A field of computing concerned with giving computers the ability to detect emotional change in humans, among other things.

Haptic Interfaces: Interfaces that use touch-based interaction (vibration, etc.) with the user to communicate information.

Mobile Devices: Computing devices that are smaller than ‘typical’ computers (such as laptops and desktops), including smartphones and tablets.

Multimodal Interfaces: An interface that communicates to a user via more than one sense (such as an interface using vibration and noise to get one’s attention).

Wearables: Very small devices such as watches and pedometers, which can gather information from an individual via being worn and communicate this information (often wirelessly) to computers.

APPENDIX: FURTHER READING

For more information regarding user experience requirements when developing for the elderly, the following resources can be consulted. Please note that the links provided are current as of December 2014, and are subject to change:

- **IBM's Accessibility Guidelines:** IBM has crafted checklists for web and software accessibility that are available online for perusal. The guidelines offered cover a range of possible material, such as live recordings and animations. IBM also lists a number of other websites for more specific accessibility guidelines. These checklists are available at http://www-03.ibm.com/able/guidelines/index.html
- **W3C Web Design and Applications Accessibility Guidelines:** While these guidelines are listed as being for websites and web applications, many parts of them (such as relying on keyboard-based input) might be applied to existing computer applications as well. These guidelines are available at http://www.w3.org/standards/webdesign/accessibility

Those interested in developing mobile applications may also wish to consult these references, which focus on application accessibility:

- **Apple's Accessibility Guidelines for Developers (iOS):** Apple's mobile platform offers a number of accessibility features, such as VoiceOver (which reads aloud text onscreen) and tools to make text bigger, built into the operating system. For this reason, iOS developers do not need to put as much work into developing changeable interface elements. However, developers do need to test to ensure their applications work with the existing features correctly. These guidelines are available at https://developer.apple.com/accessibility/
- **Android Accessibility Guidelines:** The Android mobile operating system has been gaining popularity as of late, and is used in many smartphones and tablet devices. The Android Development Website devotes a portion of the page to accessibility guidelines, and includes a handy checklist. Like the iOS accessibility features, Android has some accessibility tools built into the operating system, but also offers a checklist for the developer to test for, to ensure application accessibility. These guidelines are available at https://developer.android.com/guide/topics/ui/accessibility/index.html