1-1-2013

Considerations in Designing Human-Computer Interfaces for Elderly People

Drew Williams
Marquette University, drew.williams@marquette.edu

Mohammad Arif Ul Alam
Marquette University, mohammadariful.alam@marquette.edu

Sheikh Iqbal Ahamed
Marquette University, sheikh.ahamed@marquette.edu

William Chu
Tunghai University

Published version. *2013 13th International Conference on Quality Software (QSIC)* (2013): 372-377. DOI.

Considerations in Designing Human-Computer Interfaces for Elderly People

Drew Williams[1], Mohammad Arif Ul Alam[1], Sheikh Iqbal Ahamed[1] and William Chu[2]
[1]Depertment of MSCS, Marquette University, Milwaukee, Wisconsin, USA
[2]Dept. of Computer Science, Tunghai University, Taiwan
{Drew.Williams, MohammadAriful.Alam, Sheikh.Ahamed}@mu.edu, cchu@thu.edu.tw

***Abstract*—As computing devices continue to become more heavily integrated into our lives, proper design of human-computer interfaces becomes a more important topic of discussion. Efficient and useful human-computer interfaces need to take into account the abilities of the humans who will be using such interfaces, and adapt to difficulties that different users may face – such as the difficulties that elderly users must deal with. Interfaces that allow for user-specific customization, while taking into account the multiple difficulties that older users might face, can assist the elderly in properly using these newer computing devices, and in doing so possibly achieving a better quality of life through the advanced technological support that these devices offer. In this paper, we explore common problems the elderly face when using computing devices and solutions developed for these problems. Difficulties ultimately fall into several categories: cognition, auditory, haptic, visual, and motor-based troubles. We also present an idea for a new adaptive operating system with advanced customizations that would simplify computing for older users.**

Keywords— human computer interfaces, user interface design, elderly people, computers, mobile

I. Introduction

In recent years, personal computers have only become a more prominent part of our everyday existence. Boasting a wide variety of applications and add-ons to assist humans in going about their lives, computers now enhance many common activities - from allowing increased and better social interactions between people who otherwise would not be able to meet, to creating a collaborative and mess-free environment for artistic talents and other hobbies. Computers enhance enjoyment of new places and events by providing guides to new cities and even guiding humans through unfamiliar metropolitan areas via geo-positioning software and crowd-sourced reviews of dining and recreation establishments in the area. Information transfer is improved with collaborative encyclopedias and user-run newspapers and journals. Furthermore, nowadays a variety of computing devices have been created in order to further enhance peoples' days. Mobile devices, such as smartphones, allow for advanced understanding of the world around a user via various sensors and powerful cameras. By being with a user throughout their daily routines, mobile devices, laptops and desktops alike share parts in making common tasks even easier; allowing new information to be accessed and stored while the user is in motion, and processed and organized when the user sits at their desktop computer at the end of the day.

With these life-enhancing devices in existence, one of the most important considerations is that of proper design. An application may be helpful for a new user, but it's problematic if the design of the application or device is too poor for a user to thoroughly grasp how to best use it. Human-computer interface designers must take into consideration that every human on this planet is unique, and equipped with different abilities and different population stereotypes. Younger people, more used to technology, have different expectations of applications than older adults, who require different interfaces based on their level of understanding of tech. For a teenager, a device that allows for a swiping motion to perform a particular action might be more expected; older adults, less used to such patterns in applications, might take a bit longer to get used to such actions. Elderly adults, typically determined to be those aged 60 and above [1], have an even-more particular skillset, as they encounter declination of their physical and mental abilities with the onset of old age [15][14][13][7][4]. However, elderly adults are some of those people who would benefit most from what these devices have to offer. Applications such as note-taking software and social media could assist the elderly in remembering tasks as their cognition falters, and staying in contact with loved ones when decreased mobility does not allow them to meet in person with friends and family.

In this paper, we would like to discuss the particular interface design challenges faced when creating human-computer interfaces to be used by elderly adults. Such design challenges can be divided into multiple categories of considerations. We'll begin by stating our motivations for noting such design challenges and taking into account some examples of how poor design can prevent the elderly from using devices that otherwise could enhance their quality of life. We'll then talk about current research that is being done in the area of developing proper human-computer interfaces for elderly people, followed by commonly-seen design challenges divided into the aforementioned categories and a case study featuring a developed method of predicting falls with a smartphone. Finally, we'll discuss the notion of a user-configurable interface, available on both smartphone and laptop/desktop computers, which can adapt to a users' visual, auditory, haptic, mobility and cognitive abilities via a simple, reoccurring questionnaire and general monitoring of a users' workflow, and discuss how this might be used to better the lives of elderly people and give them a greater sense of independence.

978-0-7695-5039-8/13 $26.00 © 2013 IEEE
DOI 10.1109/QSIC.2013.36

II. Motivation

The motivation for this paper mainly arises from the number of technological advances that could very well enhance the lives of the elderly, but are nearly unusable by them due to poor design. Technology has the potential to be used in a great number of ways by the elderly: information access, delivering educational opportunities, telemedical uses, working from home, and more [9]. However, user interface design of computing devices often hinders the adoption of technology – meaning that these possibilities are not realized. For example, while some elderly people are able to use smart phones with great efficiency, others with motor difficulties find it cumbersome. While an iPhone might help a grandmother speak with her children and grandchildren, she might find that the icons are too small and too great in number, and the sensitivity of the device proves to cause many instances of incorrect input [2]. Other, more general problems are also encountered by elderly people who wish to use computers, including cognitive decline, motor difficulties, confidence problems, and general improper design of user interface elements [1]. Tasks that are simple for teenagers, such as using a mouse or remembering the details of how to view a Facebook photo album, are not so immediately understandable to an older adult [9]. And while some computers offer options to assist older users, such as changing a font or decreasing mouse sensitivity, these options are often buried in the settings for the computer overall and not easily encountered. Furthermore, often such settings need to be initiated in each program, and on each device, in a separate manner.

Other problems the elderly person might encounter when using a computer can be explored in the following situations:

Scenario One: Using a GPS. In order to visit family, an elderly person might utilize a GPS application to assist them in finding the place of meeting. However, most GPS applications offer a touch-based interface, which can be very sensitive. Older people with decreased motor skills may take more time to use the GPS system and set it up according to where they want to go, than it would take for them to use a map. Thus the elderly person to turn away from using a GPS, despite the fact that many GPS systems nowadays offer advanced features, such as automatic re-routing and traffic information, that an elderly person may find quite useful. Furthermore, even if they opt to use the GPS system, a decorative and cluttered interface displaying many options – such as surrounding landmarks, speed, direction and more – might confuse the user more than assist them, again leading them to consider using a map rather than the GPS application/device.

Scenario Two: Using Social Networking. With millions worldwide utilizing social networks in this day and age, an elderly person might use social networking websites – such as Facebook, or Twitter - in order to stay in touch with their children and grandchildren. However, multiple menus hiding various settings and possible actions, coupled with colorful designs, can often confuse and hinder efforts to use these social networks – the elderly often have less sensitivity to contrasts in color, and multiple pictures and wallpaper patterns run the risk of confusing a user [1].

Furthermore, many social networking websites feature unfamiliar terms and ideas, which can confuse older users, coupled with notions such as "status updates" that might be familiar to youth, but make no sense to an elderly user. If this wasn't confusing enough, the incredibly public nature of these websites means that an accidental input that gets posted to the social network may cause more damage to the elderly person's confidence in using such technology, causing them to – again – eschew it. Existing problems with confidence in the face of technology have been noted in the elderly population. [1]

Scenario Three: Remembering Tasks. Finally, in order to organize and remember lists of things to do, an elderly person might configure a to-do list program, complete with audible reminders when the time to complete a task comes around. This can be useful for someone who needs to remember to take medication, or a diabetic who forgets to check their meter. However, alerts should be configured to be correct for the elderly user: pop ups, for example, may not catch the elderly user's attention required [14], and if the pop ups do catch the user's attention, multiple reminders can be distressing – as elderly users show less of a multitasking ability than younger people [14]. Sometimes, the high pitched beeps of such audible reminders may be missed by the elderly [1]. Pitch aside, those who are hard of hearing may need to further adjust the levels of the sounds produced, or risk not hearing the reminders and forgetting to do their tasks despite their diligence in creating the reminders to assist themselves [14].

Taking these scenarios into account, it's easy to see that there are several particular categories of re-occurring problems that the elderly may face when using a human-computer interface. Proper design of visual components is a big factor in human-computer interface design for older adults, followed by making sure that users with different motor skills can interact with your design. Auditory displays can be useful but require proper tuning for the hard of hearing, and clutter should be reduced as much as possible in displays in order to reduce the cognitive abilities they require. Finally, in relation with the previous mention of mobility, haptic displays might be considered to reduce problems caused by a smooth, flat touchscreen.

III. Related Research

There have been a variety of solutions proposed to combat the problems the elderly face when they use computing devices. The following list is not intended to be a complete list of all related solutions, but rather a sampling of solutions that have been composed.

Many of the proposed solutions in existence seek to adapt individual programs for older users, rather than reimagining the operating system or methods of interaction with a computer. A good example of this sort of project is a project imagined by the University of Dundee, Scotland [3], where an alternative browser and email system was developed especially designed for older people, including "minimum functionality, no jargon, and with font and contrast ratio, and button size appropriate for older people" [3]. The project required a great deal of communication and collaboration between the designers and the older people testing the system, as the designers were not aware of the level to which the older people testing the system were unaware of popular terminology and common assumptions [3]. Another browser, BrookesTalk, was developed initially for blind and "visually impaired" users as a "speech output web browser" – it was revisited in order to determine why 82% of the elderly using it were unable to access the internet in a timely fashion [7]. Again, the same lack of understanding of basic computing concepts was the culprit, and so BrookesTalk found success when reimagined with a "Voice Help" system that clearly and concisely stated options for the elderly people to choose from [7]. By walking through BrookesTalk tutorials, users were able to build "conceptual models" of their systems, which aided them in using the systems more efficiently [7].

Of these projects, a portion added another component to the design – the ability to change as the user needs it, either automatically or as dictated by user comfort. One project, entitled the Hierarchical Adaptive Interface Layout (HAIL) model, involved an internet browser that changed positioning, number and size of navigation buttons depending on the "level" of difficulty a user selected [11]. A great example of this sort of software is Harvard University's SUPPLE interface, which adapts the user interface of a computer based on "a decision-theoretic optimization algorithm" to fit a user's abilities for a given device [10]. Another portion of the SUPPLE project, the Ability Modeler, allows for a test of a person's motor skills to be built in order to assist in making these interfaces, which were shown to significantly "improve speed, accuracy and satisfaction of users with motor impairments" [10]. Meanwhile, the University of Ulster, Magee Campus' evolvable interface monitors usage patterns of older users as they access the internet, and detects if a user is experiencing trouble with a particular task – such as determining if a user slower at using the mouse [4]. By examining past logs of the users' browsing activity, it would become possible to predict what action the user was attempting to take and assist the user based on this data – dynamically calling a help facility, rather than waiting for the user to initiate the request for assistance [4].

Other projects seek to simplify the entire computing experience rather than a single element (ie. Internet use, email) of it. An example of this is Eldy, software developed to be installed on a Windows or Linux PC that vastly simplifies the user interface, displaying several large, easy-to-read buttons that allow a user to read mail, surf the internet, chat/use Skype, and more [8]. Eldy has also released software for tablets with a similar function – replacing the multitudes of small and difficult to read icons on tablet screens with the large, simple buttons [8]. The interface brings common computing tasks together and clearly marks them, for better understanding of the workings of a machine without complicated jargon or assumptions of understanding.

Finally, it's important to note that a variety of device-based solutions for elderly people with more severe difficulties with mobility are also being investigated. For example, using devices to track the point of gaze of an elderly user has been determined as being "more natural and easy to use" for older people, as such a device "extracts information from natural movements and…are usually intuitive" [5]. Touchscreens also have been deemed to be more useful than other methods of computer interaction [9], when a touchscreen was pitted against a keyboard and mouse to determine which caused the best user performance, the "keyboard and mouse performance were about equal, but less than the touchscreen" [6].

IV. Considerations when Designing Interfaces

While each of the previously-mentioned research projects worked to solve different problems in the interaction between the elderly and computers, the problems they sought to solve again can be seperated into particular categories. An ideal and complete human-computer interface solution for the elderly would consider implementation of solutions to as many of these challenges as possible, if not all of them.

A. Visual Displays

Elderly people often experience a decline in various aspects of their vision, including visual acuity, presbyopia, peripheral vision, dark adaptation [14] and declined recognition of color contrast [1]. As we've seen, because of this visual degradation, poorly-sized and colored components of a program, such as the buttons, can lead to frustration on part of the user. This said, properly-designed displays for the elderly would have easily adjustable components, with color only used as needed and overly-flashy designs omitted, because of their distracting qualities. Consistent brightness would be necessary, and pop-ups might be allocated to a particular part of the screen, so they do not overwhelm. In general, simplicity is key when designing visual displays for the elderly - while visual displays for teenagers might need flash and bounce to attract their attention, too much color and action in a display will confuse and frustrate an elderly user.

B. Auditory Displays

Elderly folk also commonly experience hearing loss - by 65, 50% of men and 30% of women experience hearing loss so severe it "inhibits their social interaction" [14]. Furthermore, even if hearing is not degraded, the pitches that the human ear can hear shift in older age - higher tones, such as those above 2500Hz, are less able to be heard [1]. This said, it's important to make sure that alert tones are not only louder for elderly users, but the *correct* pitches. Something else to keep in mind is that elderly users tend to downplay or even deny any hearing loss they might have, in order to avoid stereotypes [14] - this said, someone designing an interface for elderly users might want to place volume controls in the application in an easy-to-find spot, so less work needs to be done to find the volume controls, and the users in turn don't have to spend too much time thinking about their hearing loss.

C. Haptic Displays

With the rise of touchscreen devices, accidental user input is on the rise - while touchscreens are much more popular among the elderly and better than keyboard/mouse input as we've seen, they are typically unable to be used by the blind or those with significant vision problems [15]. These devices typically do not offer any sort of haptic input for a user - there are no buttons to feel the fingers press, and no feedback to tell the user that a selection has been entered when touching buttons. Some devices and applications utilize an audio display when a user indicates a selection, making a sound or playing a short audio clip, but the user needs to listen to the output carefully, and runs the risk of missing the audio output if they aren't careful. [15] Haptic response thus can be very important in aiding a user in navigating a touchscreen display – or any other display as well. Such response could be employed via complete haptic interfaces such as the Immersion TouchSense device, which allows a user to push GUI buttons with complimentary tactile sensations [15], or simply a vibration that occurs when a user selects a button with their finger.

D. Motor Skills

A large problem that we've seen for users is that of motor skills – in a survey taken of elderly computer users for a study in coaching older users to properly use a computer, issues with dexterity and computing were most often reported, only tied with fear of making a mistake [16]. Elderly users often have a more difficult time finding little targets and make less accurate movements [1]. Arthritis and swollen fingers will also more than likely inhibit a user's ability to interact with a computer using a keyboard and a mouse [14]. This said, a display that adapts a given display not only for visual reasons, but for mobility reasons, can be quite helpful – such as the previously-mentioned SUPPLE project at Harvard University [10]. If erratic mouse movement is detected - either overly slow, or overly fast - an interface might want to adjust itself to better match the movements the user can make. In this way, the user will experience less pain and frustration when using the computer, and will more eagerly use the interface, rather than avoiding it for fear of making mistakes, as is so common in the elderly population.

E. Cognition

Finally, while each of these considerations are useful on their own, care should be taken in how they are used – in order to ensure that the device does not inadvertently cause a cognitive overload in its quest to assist a user. If a device uses a very large amount of text, or a very large amount of audio in trying to communicate with a user, it might cause the user to become distressed in trying to parse all the data thrown at them. Elderly people often don't know what to do when faced with error messages in particular [1] and this helplessness can often hurt their confidence in using computers, resulting in a fear of making a mistake inhibiting their ability to use a computer. Noise and detail can easily distract elderly users [1], who have been shown to do worse at multitasking than younger people [14]. There is also the problem of Age Associated Memory Impairment, which causes "a detrimental effect on exploratory learning" – the ability to create mental models of a given task is significantly reduced, and the common problem of the elderly having more significant problems remembering particular steps in navigation-based tasks. [4]

In order to relieve cognitive efforts, layering different modes of communication should be utilized when necessary [1], especially in order to relieve mental exhaustion that might occur otherwise. Jargon-free tutorials are requirements for introducing new programs to the elderly, and should be designed with the simple visual interfaces that were discussed earlier, and shown more than once. Attention-getting components should be used sparsely, unlike in interfaces designed for younger users, who can deal with many alerts going off at once for various aspects of the computer.

As an example of how to adapt a human-computer interface to these problems, we take the example of a recently-developed smartphone application that monitors an elderly user via the gyroscope and accelerometer, and seeks to alert the user of possible dangerous activity [12]. For a given measurement set, the user is allowed to either allow the device to automatically decide what action was taken, or manually input the activity that took place from a list of 600 activities [12].

In order to adapt an interface containing that many activities for an elderly user, one should make sure to group them in categories that go from broad to specific, taking data from users to determine the best method of grouping such categories – a balance between a quick path to the chosen action and intuitive group needs to be struck. Icons should be used to differentiate categories, as text-only listings might be problematic for those with poor vision. Furthermore, the alert tones need to be pitched appropriately and only used in emergency cases – other warnings, such as a dull vibration, may be employed to alert a user without the startling effect of a sudden tone. All of these edits will go a long way in creating a user-friendly application for the elderly.

V. Proposed Solution: Adaptive Desktop/Mobile Operating System for Elderly Users

These points taken into account, we propose the following ideal human-computer interface for the elderly user, that does a variety of things to ease these challenges, and hopefully makes computing easier for those of older ages. Elements of the interface would be as follows:

The interface would install as a new Linux-based operating system, mirroring the controls of Windows computers but with less flashy versions of the windows programs that can be configured more appropriately to a user's desires and abilities. The use of Linux, as an open-source operating system, ensures that maximum configuration to the users' abilities could be employed. The OS should have full touchscreen capabilities, but also allow mouse and keyboard input, in case a user cannot afford a touchscreen computer. The OS should be able to be frequently updated, and support new and upcoming accessibility technology, like the aforementioned haptic touchscreens [15].

On startup, the interface would take an assessment of the user's mobile, visual, auditory, memory and motor skills via a quick, easy-to-understand questionnaire. A profile would be built based on the responses to these questions, similar to the SUPPLE project [10], but encompassing not only mobility, but memory, hearing and visual abilities as well. The questionnaire would be designed to take as little time as possible - further inferences about user ability could be made by monitoring the user's interactions with the interface.

Based on user responses, the interface would adjust itself - setting particular rules on how many icons could exist on the desktop, how large the icons might be, how close together icons might be grouped, font size, alert volume and contrast settings. Difficulty with hand motor skills might cause the machine to use a mouse stabilizer, as such things have been invented to assist with making a selection [6]. Furthermore, settings should adjust to cover deficiencies of the user's abilities: if particular hearing levels were indicated, the option for a voiceover might be initiated, or the option for voice recognition to avoid involving the user in too many physical movements. If user hearing was decent but visual abilities were lacking, an audible sound might occur when an element was clicked to make up for this [6].

The desktop would contain a selection of the most-used programs automatically, so to assist the user in selecting programs. The operating system would come pre-loaded with necessary software – such as a PDF reader, office software, an internet browser, email client, and even Linux ports of commonly-used software such as Skype. The clock would be enlarged, and a help button easily placed in the corner of the screen, with tutorials easily accessible.

Jargon-free tutorials and help could be accessed using natural language - clicking the help button, and asking "How do I go to the internet," or similar questions, would bring up the appropriate tutorials. Tutorials should be written explaining with the least computer-based terminology possible – one might say "move the cursor on screen to the globe picture" instead of "click on the internet icon." If a user had indicated poor memory, the tutorials might be automatically selected at the beginning of less frequently-used programs, in order to remind the user how to go about doing simple things in them without causing the user to have to ask for help and possibly feel embarrassed at needing to ask for help. Tutorials should tell the user what actions they have taken, and what actions they need yet to take – this way, a user can develop a conceptual model through repetition, as this has shown to be a better alternative than memorization [7].

The included email and internet clients would have the capability to strip emails and websites down to the bare essentials in one click – allowing for easy parsing of flashy websites. Extracting the text from emails and websites without flash and alerts would allow elderly users to read news articles in high contrast, with easily accessible font resizing instructions included in the web browser. New organizations for popular websites that make them easier to read for the elderly user could be built into the internet client.

A single section of the screen would be dedicated to alerts. If something needed to send an alert message to the user, it would always be relegated to this portion of the screen - this avoids confusion that might occur with multiple pop-ups and flashing alarms. A single, loud, low-tone beep would alert the user to a new alert in the alert section of the screen.

Finally, to continue offering the most accessible browser for a user, the questionnaire would be re-given every so often at a set interval - be that once a week, once a month, or something similar. This would allow for proper re-organization if necessary (for example, if a user reports that their eyesight is getting slightly worse, the interface might tune itself accordingly) and allow for the interface to keep track of trends. If a user repeatedly states that their eyesight is getting worse, the interface might further tune itself between questionnaires, without asking the user first. Viewing user interaction logs might back up this sort of data. This would give the users some say in how their interactions with the program are interpreted.

Finally, the most important part of the interface would be the ability to transfer settings between devices that were using it – and developing a mobile component to the interface, that could run on a smartphone. The settings within the interface, would be able to affect how a mobile device was laid out - allowing for updating of all the devices a user owned based on the user's ability. We offer the following scenario: a user notes in their weekly questionnaire that their vision has been deteriorating on their desktop. The interface adapts, by increasing the contrast and querying the user for input.

When the user agrees to the change, the interface on the desktop alerts the paired interface on the laptop - updating the interface to the higher contrast one - and also alerting the user's smartphone. This causes the smartphone visual interface to take on similar changes – perhaps enabling vibration feedback when buttons are pressed, so the user does not need to strain their eyes to make sure a button makes a noise when selected. The smartphone visual component would be designed to look similar to the desktop, allowing for seamless use of both and proper design of components for the elderly user in both cases. Furthermore, in including this component, we are giving the elderly user the new freedom to use multiple devices, after learning one, without having to re-configure many settings.

VI. DISCUSSION

In comparison with existing solutions, our solution is much more robust. Instead of simply adjusting the visuals of the internet or email client, ours would readjust the visuals of the operating system, presenting the user with an overall easier computing experience that took into account the user's preferences in regard to font size, contrast, button size, and the like. The interface would be constantly evolving – not only based on the users' visual and motor abilities, but their hearing and cognitive abilities as well. In-depth tutorials would guide users in getting used to a computer, and depending on the questionnaires could be configured to appear often, or not-so-often if the user has a better memory.

The interface as a whole would adapt, as previously-mentioned projects, but to a wider array of abilities the user may have. Furthermore, the adaptation would be computer-wide and incredibly customizable. In addition to this, the adaptation would spread to all other machines that the user possessed – reducing the amount of configuration the elderly user had to remember to do on each computer.

It would remain to be seen if an elderly user would encounter problems running software such as games with this setup – many Windows programs can be installed on Linux-based machines with certain setups – but as this interface would be intended for the absolute beginner, who otherwise might not use a computer or an accompanying smartphone, this most likely would not be a problem. Furthermore, many open-source alternatives to game software exist – development of an "app store" of sorts might be considered to guide users to new software.

TABLE I. COMPARISON OF SOLUTIONS

Interface Solutions	*Solutions for most difficulties*	*Adaptive*	*Mobile Component*
Alternate email client/browser [3]	No	User-initiated	No
BrookesTalk[7]	No	User-initiated	No
HAIL [11]	No	User-initiated	No
SUPPLE [10]	No	User-Initiated	No
Evolvable Interface [4]	No	Automatic	No
Eldy [8]	No	No	Yes
Our Proposed Solution	Yes	Both user-initiated and automatic	Yes

VII. CONCLUSIONS

In conclusion, we have identified a number of the most frequently considered problems with human-computer interfaces and the elderly, and developed a new interface – one based on Linux – that would seek to end the distracting and confusing elements to better help an elderly user use a computer. In addition to this newfound capability, with the ability to transfer the settings to other computers running the same operating system, and even mobile phones with the mobile iteration of this interface installed, a user once restricted by poor design would be able to use a host of devices, and take advantage of many offerings previously not available to them.

It should be noted that because of the nature of this project, a great deal of user testing would be involved in the proper development of the software – other solution-seekers quickly found that they overestimated the amount of knowledge they could expect from elderly users [3], and striking a perfect balance between the knowledge to expect from the user and the lack of knowledge to make up for would be crucial in this project. Testing of the user interface of the operating system, as well as the applications that were modified to work with the operating system, would be crucial. If such an operating system were developed, the use of a user social network might be an option to consider – if elderly users could help each other, this has been shown to allow them to avoid being embarrassed by lack of knowledge [9].

Future work that might be done here includes possibilities such as adding enhanced user configuration options, such as those that might take into account that difficulties change throughout the day, depending on user tiredness or eyestrain [7]. One might also investigate designing a version of this interface that might overlay a Windows computer, allowing for more advanced users to "upgrade" to a Windows machine and slowly train themselves to use it, while staying familiar with the interface changes the Linux operating system offered to them. This would offer the elderly user greater freedom in their computing choices.

Once also might want to involve the use of additional hardware, such as the aforementioned eye-tracking software, to create a more user-specific interface that is even easier to use. Haptic devices, such as those which offer vibratory feedback based on selections [15], would also be a good fit for this interface – and evaluations of such solutions would be helpful in the future. Gestural interfaces, such as multi-touch solutions, have also been investigated as being a more natural method of interaction with a computer for the elderly [6], and continue to be researched for future use.

REFERENCES

[1] T. Phiriyapokanon, "Is a big button interface enough for elderly uesrs? Toward user interface guidelines for elderly users," Masters thesis, Comput. Eng., Mälardalen University, Västerås, Sweden, 2011.

[2] D. Zax. (2013) "Smartphone makers: Don't Leave the Elderly Behind," MIT Technology Review [Online], Available At: http://www.technologyreview.com/view/511876/smartphone-makers-dont-leave-the-elderly-behind/

[3] A.F. Newell, "HCI and Older People," in *HCI and the Older Population Workshop*, Leeds, UK, 2004, Available Online: http://www.dcs.gla.ac.uk/utopia/workshop/newell.pdf

[4] A. Hunter, H. Sayers, and L. McDaid, "An Evolvable Computer Interface for Elderly Users," in *Proc. Of Supporting Human Memory with Interactive Systems Workshop at the 2007 British HCI Conference*, Lancaster, UK, pp. 29-32

[5] R. Raya, D. Torricelli, E. Rocon, R. Ceres, A. Frizera, J.L. Pons, "Feasibility in human machine interfaces for elderly people," *Proc. Of the 6th International Conference of the International Society of Gerontechnology,* Pisa, Tuscany, Italy, 2008, Available Online: http://www.gerontechnology.info/Journal/Proceedings/ISG08/papers/051.pdf

[6] N. Hollinworth. Improving Computer Interaction for Older Adults. *Sigaccess Newsl.* Issue 93, pp. 11-17, Jan. 2009. Available Online: http://www.sigaccess.org/community/newsletter/january_2009/jan09_3.pdf

[7] M. Zajicek, "Interface Design for Older Adults," in *WUAUC'01*, Alcacer do Sal, Portugal, pp. 60-65.

[8] "Eldy Seniors Computer Software for Elderly," http://www.eldy.eu/.

[9] N. Alm, P. Gregor, A. Newell, " Older People and Information Technology are Ideal Partners," presented at the International Conf. for Universal Design, Yokohama, Japan, 2002.

[10] "SUPPLE: Automatically Generating Personalized User Interfaces," http://www.eecs.harvard.edu/~kgajos/research/supple/.

[11] J. Magee and M. Betke. "HAIL: hierarchical adaptive interface layout," in *Computers Helping People with Special Needs*. 1st ed. Berlin, Germany: Springer Berlin-Heidelberg, 2010, sec. 3, pp. 139-146.

[12] M. A. Alam, W. Wang, S. I. Ahamed, and W. Chu, "Elderly Safety: A Smartphone Based Real Time Approach," in *ICOST' 2013,* Singapore.

[13] A. Dickinson, J. Arnott and S. Prior., "Methods for human-computer interaction research with older people," *Behavior & Information Technology*, vol. 26, no. 4, pp. 343-352, July-August 2007.

[14] F. Nunes, P. A. Silva, F. Abrantes, "Human-Computer Interaction and the Older Adult: An Example Using User Research and Personas," in PETRA '10, Samos, Greece, Available Online: http://doi.acm.org/10.1145/1839294.1839353

[15] H. Nishino, Y. Fukakusa, A. Hatano, T. Kagawa, K. Utsumiya, "A Tangible Information Explorer Using Vibratory Touch Screen," in *2012 26th IEEE International Conference on Advanced Information networking and Applications*, Fukuoka, Japan, pp. 671-677.

[16] L. Kantner and S. Rosenbaum. "Usable computers for the elderly: Applying coaching experiences," in *Professional Communication Conference,* Orlando, FL, 2003