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# Towards elderly social integration using a multimodal human-computer interface

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**Abstract.** This paper presents a multimodal prototype application that aims to promote the social integration of the elderly. The application enables communication with their social network through conferencing and social media services, using natural interaction modalities, like speech, touch and gestures. We begin by discussing the requirements and design guidelines that were taken into account for the development of the prototype. We also present the key elements of the development stage and the results of a usability study conducted with ten elderly volunteers. The usability study reveals that such a multimodal solution can simplify accessibility to the considered services. Results indicate that this system is simpler, more natural and more enjoyable than the current user interfaces. Furthermore, the natural interaction modalities of the proposed prototype, allow elderly to be more efficient and have a better user experience, thus contributing with an easier and faster way for this population to join the information era.

**Keywords:** Social inclusion, elderly, multimodal interfaces, usability evaluation, speech, touch

## 1. Introduction

This paper proposes several ways for reducing the impact of social exclusion observed in the elderly population. However, to effectively mitigate that issue, one must take into account the fact that those individuals have developed resistance to conventional forms of human-computer interaction, like the keyboard and mouse of the WIMP paradigm, for instance, therefore making it necessary to test new natural forms of interaction such as speech, touch and gestures. In addition, elder people often have difficulties with motor skills due to health problems such as arthritis, so the absence of small and difficult to handle equipment may be presented as an advantage over current solutions. It is also known that due to ageing, senses like vision become less accurate (Quillen, 1999), hence difficulties in the perception of details or important information in conventional graphical interfaces may arise, since current interfaces, most notably in the mobility area, are not designed with these difficulties in mind.

There is also evidence that the European Union (EU) population is ageing rapidly. The European Commission (2010, p. 168) estimates that by 2050 the elderly population in the EU will be around 29% of the total population. This means that it is hastily becoming necessary to create solutions that allow overcoming the difficulties age brings to people who want to use new technologies in order to remain socially active.

In this paper we present an adaptation made to the Living Home Center (LHC) prototype developed by Pires et al. (2011), which was specifically targeted at the mobility impaired population. We have extended the services supported by that prototype, by adding support for Instant Messaging, as well as integration with the Facebook social network, enabling access to messages and photo albums. This paper also presents two user studies, the first one that allowed gathering user requirements for the development of the prototype and, the second one, which performed a usability evaluation, aiming at testing if the proposed solution is actually useful to elderly people.

The remainder of this document is structured as follows: Section 2 presents a review of related work in the area of assistive technologies for seniors. Section 3 describes the results of the initial user requirements study, from which we derived design guidelines and gathered knowledge about the elderly. Section 4 explains the choices made during the prototype development and adaptation stage. Section 5 provides an analysis of the results obtained in the usability evaluation study and presents a discussion of those results. Finally, section 6 presents the conclusions and outlines future work.

## **2. Assistive Technologies for Seniors and Multimodal HCI**

Elderly people who are connected to the world through the internet are less likely to become depressed and have greater probability of becoming socially integrated (Cisek and Triche, 2005). However, despite being the population group that is more rapidly going online (Pew Internet & American Life, 2006), technological and interaction barriers still do not allow seniors to take full advantage of the available services and content (Sfyraakis et al., 1998).

With the objective of allowing older people and people with disabilities to live independently and be active in society, some initiatives have been launched by the European Union. A good example is the e-inclusion project (Europe's Information Society, 2010), which *“aims at reducing gaps in ICT usage and promoting the use of ICT to overcome exclusion, and improve economic performance, employment opportunities, quality of life, social participation and cohesion.”*, by, for example, proposing a series of measures to promote take-up of digital technologies by potentially disadvantaged groups, such as elderly, less-literate and low-income persons.

Some studies, such as D'Andrea et al. (2009) and Salces et al. (2005), have demonstrated that multimodal solutions can be used to improve the usage experience by a variety of user groups, including the elderly. Therefore, if provided with the means of multimodal interaction, elderly can experience improved accessibility to

information and an increased ability to socially integrate (Richter and Hellenschmidt, 2004). Multimodal User Interfaces (MMUIs) also provide users with the ability to choose different modalities depending on usage context, environment conditions or users special needs. This allows, for example, improving stability and the robustness of speech recognition based systems. The possibility to seamlessly alternate between input modalities is another advantage of MMUIs, helping reducing the probability of injuries due to the overuse of a single modality (Oviatt, 2001; Oviatt et al., 2000).

However, for the development of appropriate solutions with high accessibility one must also take into account the specificities of universal design (Dix et al., 2003, chap. 10) as well as user perspectives, thus avoiding the usage of inappropriate content, font or graphical elements size, for example (Júdice et al., 2010).

### **3. User Requirements Study**

With the objective of gathering information about the main problems senior citizens face while using the computer and current graphical user interfaces (GUIs) for Communication (e.g., Windows Live Messenger (WLM)) and Social Media Services (SMSs) (e.g., Facebook), we have conducted a requirements analysis study that allowed the definition of a list of key requirements to be considered.

The study was divided in three parts. In the first part, we have performed a structured interview using a questionnaire. In the second and third parts, we have asked participants to carry out a set of tasks, first with existing communication and social media services and afterwards with the LHC prototype, which was designed for people with mobility impairments (Pires et al., 2011). For the creation of the experimental tasks and decision of the analysis methods we have followed the guidelines provided by Dix et al. (2003, chap. 9). The goal of these tasks was to gather information about which modalities would better satisfy the needs of the elderly. We have also aimed at gathering some data concerning the participants' reactions and opinions about the current LHC version. By doing so, we wanted to find out which changes should be taken into account for the newer version of the aforementioned system.

#### **3.1. Study participants**

Ten elderly people took part in this requirements study. All the participants were volunteers from the Lisbon University for Seniors (<http://ul3i.com.sapo.pt/>). The selection of the participants was done randomly, however with a few restrictions, as different computer skills and ages between participants and, especially, high literacy levels were required.

The study group was composed of 2 males and 8 females, since it was difficult to recruit an equal number of participants of each gender that fitted the desired profile. The participants had an average age of 66.3 years old and different careers. As requested, most of them presented high education levels, since that aspect "*plays a significant role in the way the user interacts with computers*" (Júdice et al., 2010, p. 108).

### **3.2 Analysis of the participants' skills and habits, via questionnaire**

The goal of this questionnaire was to determine computer, mobile phone and smartphone frequency of use, nature of use and demonstrated skills, as well as habits of usage of communication services and SMSs. This part was exclusively self-assessing.

Interestingly, we have registered that the computer is not yet seen as a tool to communicate with others, since participants mentioned having difficulties understanding the current communication services UIs (e.g. WLM). They often said that they could not get those kind of programs to work, or that they had a hard time trying to add a contact to their friends list or establishing calls. The majority of the considered sample also declared not using any SMS even though they knew of these services existence. They argued that they heard too many times in the news and by friends that using such a service might be dangerous and could lead to unpleasant situations, if they did not know exactly what they were doing.

Concerning the usage of mobile devices, participants recognized using them, however the adherence to smartphones was null, mainly due to confusing UIs, too many features and small icons and text.

These results allow us to determine that our solution must provide access to an easy-to-use communications service, with few and clear options, in order to mitigate the difficulties mentioned above with current solutions. We also acknowledged that the current SMSs have too many features, as far as elderly are concerned, and require too much attention and skills. Therefore, we propose providing access only to the features seniors considered most relevant (e.g., photo sharing and messages), and to make the interface as easy and seamless to use as possible, thus trying to diminish the observed feeling of insecurity while using such service.

We also intend to introduce a mobile application for smartphones that provides the same services as the desktop version and attempts to overcome the difficulties mentioned above.

### **3.3. Usability evaluation of current UIs for communication and SMSs**

On the second part of this first study we have asked the participants to do three different tasks using current communication and social media services UIs: (1) instant messaging task; (2) conferencing task and (3) Facebook task. The goal of these tasks was to perform a usability evaluation of those kinds of interfaces concerning the usage by senior citizens.

After the evaluation of an instant messaging task using WLM, we have confirmed the results of the previous section. So, we have considered that it is important to change the way information is shown. Text and buttons must be bigger, so it becomes easier to find a contact or option. There should be buttons for tasks like opening a new conversation and submitting an instant message, avoiding the need for double click, double tap or usage of a special keyboard key, since the elderly have difficulties performing and remembering those actions. Furthermore, it is important to have an easy way of inserting special characters, since most participants were unable to insert the '@' and '€' characters using the keyboard. Touch and speech should be

considered for this feature. Speech should work for command and control, but especially for dictation when writing a message, since tests have demonstrated that participants tend to be less productive when writing on a keyboard. It is also essential that contacts are well identified, with name, a number and picture, if possible.

After completing a task that tested Facebook's usability, participants confirmed that this service had too many features, as mentioned in the previous section. We have also confirmed that there is the need to make icons and text bigger and to organize it better, since the current solutions UI elements are too small and do not always follow the same logic of space organization, from screen to screen.

Tasks analysis revealed that participants took, in average, 1:29m (conferencing task), 4:30m (instant messaging task) and 08:33m (Facebook task) more than the control subject to complete the tasks. While differences between skilled and non-skilled participants were 0:27m, 03:10m and 04:56m, in the mentioned tasks. These results allowed us understanding that some of the considered services do require some level of experience, preventing less skilled users to be as effective while performing the same tasks. We also registered that all the participants needed, in average, 2 aids per task, so they could finish it.

### **3.4. Usability evaluation of HCI modalities using the previous version of LHC**

On the third part of the first study, we have introduced participants to the previous mobile and desktop versions of the LHC prototype, which were designed specifically for mobility impaired individuals.

This part of the study allowed us to conclude that the elderly would be satisfied with an application designed following similar guidelines as the previous LHC version for mobility impaired individuals, since we have registered good levels of performance and high levels of satisfaction when we have asked them to test it. We have also observed that they normally felt much more relaxed using the prototype than the previously tested solutions, so it became obvious that this application has the potential to contribute for a more enjoyable user experience, concerning the elderly individuals as well.

We have likewise determined that touch would be a critical modality to consider, since the design of this application is completely adequate for touching, due to the size and organization of the items. Nonetheless, we have considered speech as a must-have modality too, as some of the elderly are less able to use touch, due to health problems, such as arthritis (Makover and Zieve, 2011).

## **4. LHC Prototype Adaptation**

Based on the results of the user study we have gathered requirements that enabled us to extend and improve the LHC prototype. As for specifications, we have focused mainly on the improvement of the UI flow, on the support of more social media services and on the prototype's performance enhancement, while keeping the same system architecture for the Living Home Center (LHC), with client, server and cloud

elements adhering to Microsoft technology, as described in the paper by Pires et al. (2011).

Even though no major changes on the desktop application UI were required, we had previously learnt that users could benefit from the integration of Facebook's content in the prototype, since that is one of the most popular SMSs to date, with currently more than 750 million active users, according to Facebook (2011). We have realized that elderly would welcome also an instant messaging service, given its popularity. Bearing that in mind, we have added features allowing access to Facebook's messages, profiles and also supporting media access and management, such as photo albums. We have also added support for the insertion of *comments* and *likes* on messages, albums or photos, from both the LHC users and from people in their social network.

We have also developed a new version of the prototype for the Windows Phone 7 (WP7) platform (migrating from Windows Mobile 6.5), with increased stability of that OS, the capacitive display of the newer devices, the larger memory and processing power those same devices offer, as well as the ability to use multi-touch. Figures 1 and 2, show the mobile and desktop versions GUIs of the enhanced LHC on different contexts.



**Fig. 1.** Mobile Home Screen



**Fig. 2.** Desktop Photo Album Screen

## 5. Usability Evaluation Study

We have conducted a usability study, following the method proposed by Preece et al. (2002), to evaluate how the enhanced LHC prototype performed, when used by a group of elderly individuals. Additionally, we have gathered that group's impressions about the prototype and their evaluation about its value when considered as a tool to promote social integration.

### 5.1. Study participants

For this study we have asked for the collaboration of ten participants. This time those were users of the Social Welfare Institute for the Armed Forces

(<http://www.iasfa.pt/>) in Lisbon, Portugal. For the selection of elderly, we have maintained the requirements described on section 3.1.

The study group comprised 5 males and 5 females, with an average age of 77.9 years old and different careers. This time we have also requested for participants with different literacy levels, since we wanted to register the differences between those with lower and higher levels of education, while using the prototype. For calibrating the study tasks and for comparing results, a neutral user, called the control subject, performed the structured tasks. The control subject was a female with 22 years old, who studied Marketing, had high computer skills and had never been presented to the prototype before, hence being in the same conditions as the study participants.

## 5.2. Tasks and Methodology

Six different tasks were created to test different features of the improved LHC prototype. Three tasks were designed to be performed on the mobile client and another three designed for the desktop client. In both clients, tasks focused on the usage of conference's IM and video-call features, SMS profile feature, SMS messages feature and SMS audio-visual feature. Besides *hardware (keyboard and mouse)*, different HCI modalities were always available for each task and client platforms, such as *speech, touch* and *3D gestures* in certain mobile application contexts.

To be able to gather relevant information and maintain the same conditions for every participant, a protocol was created and followed for all the sessions. The protocol creation was guided by the work of Dix et al. (2003, chap. 9).

After completing all tasks, each participant answered a final questionnaire, with open and closed questions, with the objective of determining the satisfaction with each HCI modality in terms of easiness and enjoyment, and also to evaluate the efficiency of the UI and the considered features.

In order to evaluate a task, both qualitative and quantitative results were taken into consideration, following the same recommendations as the tests made with the previous version of this prototype (Pires et al., 2011). Although quantitative results were gathered these must not be seen as the most relevant data, because of the reduced number of participants considered, the sample is statistically unrepresentative. However, it should be seen as a pre-test or a guide, to a future test with a more representative sample.

## 5.3. Tasks results

Results for the mobile application tasks show that the difference on the average times of execution, between the control subject and the participants varied from 1:14m to 1:56m, while differences between skilled and non-skilled users would not exceed 35 seconds. The task that required the visualization of the received and sent social messages was the one with the better results, as depicted in Figure 3.

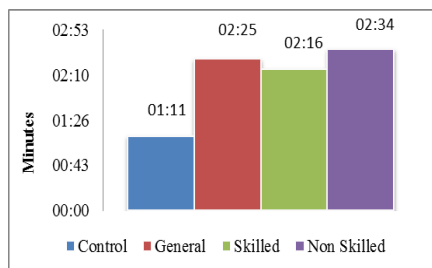
The number of aids was similar to all the tasks. Only 5 participants out of 10 requested help, and the aids did not exceed 1 for each one of those participants. The preferred modality of interaction was *Touch*, with an average of 10 uses per task per



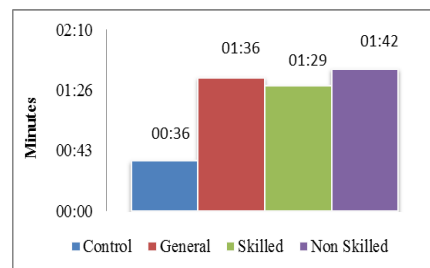
participant. Most participants argued that the “push-to-talk” (PTT) mechanism available in the mobile version was complicate and was of little help for achieving the desired action. Other issues pointed to the mobile application included the fact that the virtual keyboard is not large enough to enable elderly users to hit a key at a time and also, the fact that some buttons are hidden and not obvious enough, such as the *Save Profile* button in the SMS’s Profile screen.

Desktop tasks analysis revealed that participants took, in average, from 1 minute to 4:26m more than the control subject to complete the tasks, whereas computer skilled participants were 12 to 36 seconds faster than non-skilled participants.

The task that required the users to establish a video-call with a specific contact was the most enjoyed and that feature was reported as the most useful in the application. It was also the fastest task and the one with fewer differences between user categories, as shown in Figure 4. The video-call task was also the one that registered less aids, with only 5 participants requesting help one time. The remaining tasks registered the average of an aid per participant per task. However, if we consider that those aids had mostly to do with them asking how to bring up the built-in virtual keyboard, we could overlook these data.



**Fig. 3.** Mobile social messages task average execution times.



**Fig. 4.** Desktop Video-Call Task Average Execution Times.

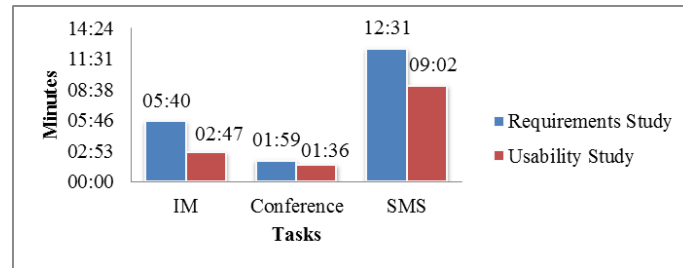
The preferred modality of interaction was *touch*, followed by *speech*. In average, it was used 3 times more than the *speech* modality and 15 times more than *hardware (keyboard and mouse)*. The only issue reported by users had to do with the fact that dictation with the current European Portuguese speech recognition engine is still far from being 100% accurate, especially with the elderly voice, since a parallel project (LUL) is still on-going with the objective of collecting those voice characteristics for the augmentation of the aforementioned engine capabilities. Satisfaction with the appearance and organization of the UI was also noticeable, as most participants commented that the appearance and organization of the screens was appealing and easy to understand.

#### 5.4. Results discussion – Requirements study vs. Usability study

At this point we could compare times of execution for similar tasks when using currently available UIs for communication and SMS services, in one hand and LHC, in the other. Concerning that case, we have considered only tasks performed with

desktop clients, since in the requirements study, we did not consider the mobile versions of those UIs.

As shown in Figure 5, in general LHC has allowed users, to be more effective performing all tasks, when compared to the existing GUIs of Windows Live Messenger (IM and Conference) and Facebook (SMS).



**Fig. 5.** Requirements Study results Vs. Usability Study results

Not only did users take less time performing tasks, they also needed less aids when using LHC. As referred above they needed, in average, 1 aid per task using LHC, opposed to the 2 aids per task using other UIs.

### 5.5. Questionnaire results

The questionnaire was based on the one applied on the previous usability study made with mobility impairment users (Pires et al., 2011). Participants generally considered all modalities easy or reasonably easy to use, and only on some cases difficult. Participants enjoyed using almost all modalities, tending to prefer *touch* and *speech* on the desktop version. Eight participants manifested preference for *touch* on the desktop application. *Speech* on the desktop application, was selected by 4 participants. The less enjoyed modalities were *touch* and *3D gestures* on the smartphone. We have asked participants if they felt the prototype interface was easy to use, obtaining positive response from all the participants. The preferred version of the prototype was, unanimously, the one developed for desktop computers.

When asked what they thought we should change or add to the prototype, so it would behave according to their needs, participants simply responded that they'd like us to change the mobile keyboard layout and enhance (European Portuguese) speech recognition for command and control and, especially, for dictation.

## 6. Conclusions and Future Work

The usability evaluation allowed us to derive the following conclusions:

**(1) The prior prototype GUI was actually adequate for the elderly too**, being classified as simpler, more natural and more enjoyable than current UIs (e.g., WLM and Facebook). **(2) Multimodality and universal design play an important part on**

**fighting e-exclusion**, confirmed by the fact that all the participants revealed to be relaxed, entertained and effectively using the prototype, achieving relatively complicated actions with little effort. Also, allowing different users to choose the modality that was most suited on different contexts, made the application being usable for both low and high skilled participants. **(3) The availability of touch, on both clients, is very important and has a direct impact on the elderly performance and level of satisfaction.** **(4) Speech is seen as an important modality**, especially for individuals that have issues using their arms or hands. However, because the accuracy of the current *speech engine* for *European Portuguese* for elderly is still undergoing improvements, participants became somewhat disappointed with the current dictation capability, describing its enhancement as a must-have feature and a good solution to their limitations when trying to use a keyboard. **(5) The desktop client version is the one that better suits the current elderly population**, since its use did not present difficulties to most of the participants. Regarding the mobile version, there are some improvements to be made, such as the simplification and augmentation of the virtual keyboard. The latter was also seen as a tool for the elderly of the future, since those will have more experience with such devices. **(6) The prototype services are useful in fighting social exclusion, improving the elderly ability to communicate and share.** As an example, users regarded the usage of the video-call feature on LHC as much simpler than with common systems, and believed it would be one the most useful services to enable communication with family and friends.

Bearing in mind that the control subject had much higher computer skills than all the participants, the results obtained in the usability study can already be interpreted as very good indicators for further research. The comparison between current UIs for communication and SMSs and the LHC prototype also gave good pointers for the evaluation of the overall LHC performance.

Future work should consider the improvement of speech recognition for the elderly, focusing especially in the dictation mode, improving the desktop UI design and the mobile version's virtual keyboard. It's also desirable to investigate if the prototype would be welcomed and usable in a real live scenario and if these results are repeatable with a larger group of users.

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