The Design and Evaluation of a Pen-Based Computer Interface for Novice Older Users

Dante Arias-Torres
Faculty of Sciences, UABJO
dante@fciencias.uabjo.mx

Abstract

The population of older people is growing rapidly worldwide, so it is necessary for all governments to provide them more services in order to improve their quality of life. In a digital era, most of these services can be provided by information technologies. However, older people have a very limited computer use due to economical, physical, sensory and cognitive barriers. In addition, few efforts have been dedicated to the design of specialized computer interfaces for them despite the fact that they have computer interaction problems with the WIMP standard (Windows, Icons, Menus, and Pointers). Recently, some researchers have shown that older people have a better computer interaction with the use of direct-manipulation devices such as digital pens than with indirect-manipulation devices such as the mouse. This research goes one step further, proposing and analyzing a pen-based interface for older people in order to explore the usability of gesture paradigm for them.

1. Introduction

As the use of computers become increasingly ubiquitous in our society, it is more important to ensure that electronic media are accessible to everyone. However, in many countries there is clear evidence that computer and associated services such as Internet are not accessed by the majority of the population. For example, in Mexico, only a 28.5 percent of the total population uses a computer and only 17.7 percent access Internet [10]. If we analyze these statistics by user age, the percentages of some population sectors are especially worrisome because these people are an important part of the population. For example, with a population of 8.2 million [5], Mexican older people represent the sector with the least computer and Internet use with 2.9 and 2.3 percent of the above statistics, respectively [10]. This fact reveals the existence of a social problem not only in Mexico but also in all countries [4]. Therefore, in order to provide more services like entertainment, news and companion, it is necessary that older people are able to use information technologies.

Older people differ from typical computer users in many ways. They are unfamiliar with computer jargon or with computer interfaces [8]. Moreover, a significant proportion of these people have physical, sensory and cognitive barriers to computer use such as learning difficulties, visual impairments, manual dexterity problems and in some cases, technophobia [7] [16].

Despite these well known problems, most developers rarely consider the implications of age-related changes for interface design. Moreover, until now all computer accessibility efforts for older people have been focused on the application level (they are variations of existing programs like web browsers and e-mail systems) and basic accessibility features provided by the operating system (OS). However, in order to be able to use and configure these programs, they need to interact with current operating system interfaces based in the WIMP (Windows, Icons, Menus, and Pointers) standard that were originally developed for the mouse which is especially difficult for them [11].

Recently, Rau and Hsu [17] showed that older people have a better computer interaction with direct-manipulation devices (touch screen and digital pen) than with indirect-manipulation devices (mouse and keyboard). This result suggests that these devices can be used like default input interfaces for them instead of the mouse and keyboard in order to improve the system usability [14].

This research goes one step further, proposing and analyzing a pen-based graphical user interface for novice older people, based on the crossing paradigm [1]. This research effort is well justified because it is known that the current operating system interfaces are not suitable for pen-based computer interaction. For example, a simple "double click" is easy to perform in

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a mouse environment (since the pointer is stable), but it proves to be quite difficult in pen-based interfaces [2].

It is important to emphasize that the approach taken here are not suitable for people with severe hand illnesses. These people require the design of computer interaction techniques that are not based on the use of a precision hand device like a pen. Although the 26 percent of older people have hand osteoarthritis and the 10 percent of these population have some kind of hand tremor [6] [18], the percent of older people without these two severe hand illnesses is still high. Therefore, many older people are able to use a pen or a mouse like a computer input device. Thus, it is interesting to compare these two devices (mouse and pen) in order to know which device is the more suitable for novice older users without a major hand disease. This knowledge can be used to provide the best interfaces for older people in order to decrease the learning curve.

2. Motivation and design goals

As noted previously, current operating systems use graphical interfaces that are not appropriated for older people mainly because they have interaction troubles with the mouse and, therefore, with WIMP interfaces, so the current GUIs impose a barrier to computer use for them.

Pen-based interfaces promise to be a successful technology for older people because it is a familiar interface. The majority of these people are used to write with a pen, rather than with a keyboard. Moreover, pen use results in a more neutral posture (a neutral posture is the position that parts of the body assume when completely relaxed) than during mouse use, which makes it a bio-mechanically superior input device [9]. However, the transition from keyboard and mouse to pen is not straightforward because the current WIMP standard is not very well adapted to pen-based interactions. Some research efforts attempt to solve this problem with novel widgets (an object used to hold data and present an interface to the user) and interaction techniques (see for example [2]). To the best of my knowledge, these efforts haven't been proven with older people.

This paper shows a pen-based graphical user interface for novice older users that explores the use of gestures as a main computer input technique instead of mouse and keyboard for older people. The proposed interface doesn't deviate substantially from the existing WIMP interfaces, but it combines some widgets in order to improve system usability (following a similar approach to Debian Jr. Project[1]). The following principles [14] were used in the interface design because they take into account many factors useful for older people, these are:

- Simple and Natural Dialogue: The user interface was simplified as much as possible, since every additional feature or item of information on a screen is one more thing to learn, one more thing to possibly misunderstand, and one more thing to search through when the user looks for something. The ideal is to present exactly the information that the user needs -and no more- at exactly the time and place it is needed.
- Minimize user memory load: Computers are very good at remembering things very precisely, and as such it should take over the burden of memory from the user as much as possible. This is more important in computer systems for people with memory problems. To minimize the user's memory load, the system should be based on a small number of pervasive rules (for example generic commands) that apply throughout the user interface.
- Avoid modes: Modes are frequent source of user error and frustration and should be avoided if possible. Modes basically partition the possible user's actions such that not all actions are available at all times, which can be frustrating.
- The minimal manual: Experiences have shown that users do not read large manual, so a computer system must allow to the user gets started doing useful work immediately after they start using the system.

3. A pen-based interface for novice older users

In order to provide an interface based on the usability principles described in the last section, two key technologies are combined: gesture commands and handwriting recognition. Gesture (to write or draw a symbol with a pen) is the most common way for inputting data or commands in a pen-based interface. Gesture input includes handwritten character data input and hand-drawn icon input for non-character data or command. Gesture commands are generally the hand-drawn iconic commands to instruct the device to do an assigned operation. Handwriting recognition is the process of converting handwritten notes into digital text using a digital pen. Nowadays, there are many

[1] http://www.debian.org/devel/debian-jr/index.en.html

gesture input systems [12]. The main difference between them and the proposed interface is that the latter suggests a new gesture set based on straight lines in order to minimize the mental workload. Moreover, it avoids the switching task between command execution, text input and drawing input, which is a typical problem in pen-based interfaces [13]. Finally, this approach proposes a universal use of gestures in common operating system tasks. The following subsections describe the interface components and interaction techniques that allow the following key activities: system navigation, command execution, and desktop interaction.

3.1. System Navigation

When the user starts using the system, a system navigation window is shown with the typical programs and common options. Users only have to draw a straight line over corresponding icons to execute a program, to configure the computer and to manage files. When an option is selected, this initial window disappears and a window with more options is displayed. These navigation windows are closed when an action is executed. Figure 1 shows the main menu window with a gesture command drawn over an icon. This approach eliminates the necessity for the older user to search for a program or system option in nested menus that are hard to use [3].

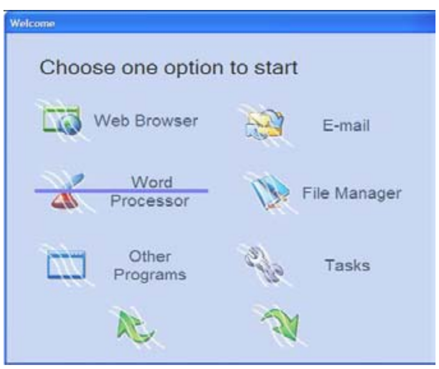

Figure 1. Main menu window

3.2. Simplified Command Execution

Nowadays, gesture command systems are based on complex gesture sets that require a training period in order to be able to use the system without help. To avoid this approach, only six gestures based on to draw straight lines (Figure 2) are defined in order to use the entire system; more complex behavior is obtained by means of contextual menus (see section 3.3). The command executed dependents on the line direction (red arrow in the figure 2). These gesture commands are universally applied in all programs and system objects such as files, folders, etc.

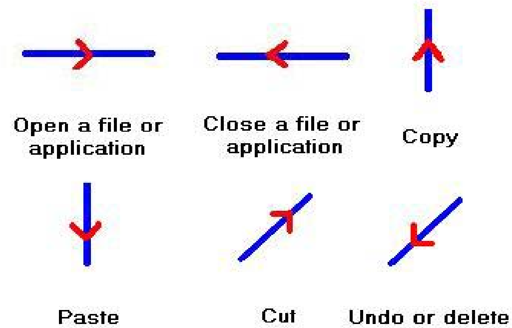

Figure 2. Gesture Set

3.3. Contextual Menus

More complex commands or actions are executed by means of contextual menus. This means that when an action is needed, a menu is displayed on the screen with options determined by the object to be processed. This avoids having to memorize many gesture commands. Explicit mode selection is avoided with a special program that supervises all application events and infers the appropriate action to be executed based on the currently selected widget and program.

3.4. Desktop Interaction

In order to simplify desktop interaction, a gesture-activated taskbar with a live thumbnail set is provided so that the user can see what programs are open and minimize and restore windows (Figure 3).

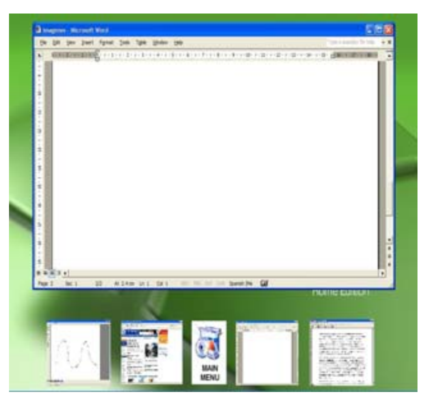

Figure 3. Thumbnail-Based Taskbar

This widget is similar to "Windows Flip" on Microsoft Windows Vista. When a window is minimized, a thumbnail that shows the content of the window at the bottom of the screen is created. A user only has to draw a straight line over this minimized representation in order to return the window to its original state. On other hand, when a user draws a similar gesture over an active window, this is minimized (see Figure 2). When the quantity of thumbnail is too big, the user can scroll the taskbar (by means of a contextual menu) to see thumbnails that are not shown. At any moment, only one window can be active, so user confusion is reduced. All thumbnails have the name of the program or document below them. Moreover, it does not allow any windows to go beyond the edges of the screen and an active window is automatically resized in order not to hide the taskbar. Also, an icon on the taskbar is included in order to achieve an easy access to programs and systems options (system navigation window, see above).

4. Evaluation

In this paper is explored the use of a digital pen as default input interface for novice older users. To the best of my knowledge, the feasibility of the gesture technology hasn't been proved for older people. In order to do it, a prototype was development and a usability study was realized. Following subsections describe the experiment environment. The main research question addressed by this study was the following:

- Is a pen-based interface learned and used more easily that a mouse-based interface for older people?

4.1. Venue

The investigation took place in a vacant office within the Faculty of Sciences at UABJO (Benito Juarez Autonomous University of Oaxaca) in Mexico. The office was chosen based on the distance from the main communal areas, so as to minimize disruptions. Computer science students participated as staff members in the experiment.

4.2. Participants

Thirty healthy novice older users between 60 and 83 years, comprising 18 females and 12 males, took part in the investigation. All of them are novice computer users with a formal education very different from illiterate people to higher educated people. Thus, the people that participate in this study describe perfectly the educational situation of this population sector in developing countries like Mexico.

Participants were randomly assigned into one of two groups (pen-based system and mouse-based system), 15 participants per group. The average age of the participants in the pen group was 65.3 years (standard deviation = 7.7); the average age of the participants in the mouse group was 64.2 (standard deviation = 8.2). One participant was left-handed and the rest of the participants were all right-handed. Participation was on a voluntary basis.

4.3. Procedure

Each participant was recruited and introduced to the experimenter by staff members. The researcher thanked the participant for volunteering to take part in the investigation and ethical considerations concerning their consent, withdrawal and confidentiality were explained. They were also informed that the tasks that they would be asked to do was not a test of their intelligence.

All participants began by filling out a general-information questionnaire concerning their personal characteristics like age and education. Each participant was given on-screen instructions, depending on the type of manipulation device assigned (pen or mouse).

A brief practice session was then conducted to help the participants understand the operation of the system and the tasks to be performed. When the participant had assured the experimenter that they fully understood the task and that they were ready to proceed, the task began. The participants were instructed to perform the tasks as quickly as possible without sacrificing accuracy. This procedure was repeated for all activities.

On the competition of the tasks, the participant was asked to complete SUS[2] (System Usability Scale) questionnaire, a qualitative usability evaluation tool. Finally, the participant was thanked and asked if they had any questions. Questions were answered appropriately and a staff member was contacted to escort the participant from the room.

4.4. Experimental Design and Variables

The independent variable was the manipulation device (mouse or pen) and the dependent variable: system usability. System usability was measured by means of SUS scale that covers a variety of aspects of

[2] http://www.usabilitynet.org/tools/r_questionnaire.htm

system usability, such as the need for support, training, and complexity, and thus has a high level of face validity for measuring usability of a system. This methodology was selected because the questionnaire used is easy to understand and to apply. Thus, the participants have less confusion and mental workload when answer the questionnaire. Moreover, SUS questionnaire is very robust and has been extensively used and adapted. It is public domain and is the most strongly recommended usability questionnaire. SUS scale yields a single number representing a composite measure of the overall usability of the system being studied. SUS scores have a range of 0 (very poor usability) to 100 points (very good usability).

4.5. Materials

I used a notebook computer with a Wacom pen tablet (Graphire4 Tablet) and a mouse for my experiments. The propose interface (a prototype) was developed using EPL[3] (Easy Programming Language) and Strokeit[4] an advanced gestures recognition engine and command processor that was adapted to pen input. All these programs were developed for Windows XP operating system.

4.6. Tasks

The gesture input is key technology used in the proposed interface (menus, files, and all objects are handled by gestures) following the crossing paradigm [1]. In order to answer the main research question addressed by this study (see above), the gesture set were tested (see section 3.2). The participants were asked to perform three activities that combine two or three gesture commands (see Figure 4).

Figure 4. A participant (a 65-years-old man) using the proposed gesture set

There were three consecutive trials of each task for each participant. In the first task, the participants used the open and close commands. In the second task, the participants used the copy and paste commands. Finally, they used the cut, paste, and undo commands.

5. Results and discussion

The demographic characteristics of the participants were gathered through the pre-session questionnaire. Participants have low levels of formal education (the average years of formal education is 6 years). The low education background of the participants distinguishes this study from previous investigations [15] [17]. To the best of my knowledge, no comparable study analyzing the usability of pen technology by older people with low educational backgrounds has ever been published.

Reliability is very important issue that all kinds of testing need to pay attention. Reliability of usability test is a problem because of the huge individual differences between test users [14]. For usability engineering purposes, one often needs to make decision on the basis of fairly unreliable data, and one should certainly do so since some data is better than no data. Due to the small number of participants, no strong conclusions can be obtained. However, the obtained results suggest that older people prefer the use of a pen to the use of a mouse as a main computer input device. This is a preliminary evaluation that tries to motivate further research in a little studied topic.

The usability results obtained by means of the SUS questionnaire were summarized in Table 1. According to these results, it was observed that older people can learn to complete the evaluated activities with the pen faster than with the mouse.

Table 1. System usability by input device

Input device	SUS average score
Pen table	52
Mouse	35

Moreover, they consider the pen-based interface easy to use and intuitive. Finally, all participants said that they preferred my proposed gesture set based on straight lines (figure 2) rather than complex symbols like letters. It is important to say that the left-handed participant was able to use the gesture set without problems.

[3] http://www.eplsw.com
[4] http://www.tcbmi.com/strokeit/

6. Conclusions and future work

This paper shows some initial steps toward a pen-based interface for novice older people. A prototype was developed and tested with some novice older users. System usability was evaluated by means of SUS methodology and compared with the mouse-based interface. The results show that novice older users can learn and use a pen-based interface more easily than a mouse-based interface. The significant contribution of this study is the analysis of gesture input in novice older users with low education, the result obtained suggests that gesture paradigm can be a successful tool to introduce them into digital era. Even though results show the usefulness of gesture input for novice older users, it is required a larger sample of participants to produce a more valid conclusion. At this time, I continue the system evaluation in order to verify the results showed in this paper.

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