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Developing a Multimodal Interface for the Elderly

Élvio Rodrigues[a], Micael Carreira[b], Daniel Gonçalves[b]

[a]*Instituto Superior Técnico, Avenida Rovisco Pais, 49, 1050-001 Lisboa, Portugal*
[b]*INESC-ID, Rua Alves Redol, 9, 1000-029 Lisboa, Portugal*

Abstract

The elderly remain excluded from technology, since they regard traditional computer interfaces as overly technical and difficult to use. However, the older users consider other forms of interaction easier to use – like touch and gesture recognition interfaces. Regarding the touch interfaces, we focused on text-entry tasks and developed and tested 5 virtual QWERTY keyboard variants in order to improve text entry speed and accuracy on tablet devices. Preliminary user tests with young adults revealed that soft keyboards without visual changes remain the fastest method for text entry, and allowed us to rule out the least promising variants. Regarding gesture recognition, we developed regular gestures as well as alternative functionalities based on the motion sensing device: user and ambient sensing. These features allow to create a more intelligent system that reacts to the user and environment without explicit interaction. In the near future, we will perform tests for both interaction modalities with older adults.

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Keywords:
Multimodal interfaces; elderly; multi-touch tablets; body gestures; text-entry performance

1. Introduction

In our daily life, we find ourselves surrounded by technology, which enables the creation of new opportunities and forms of social interaction, instant information access, constant availability and higher control of the surrounding environment. New solutions of Human-Computer Interaction (HCI) are making our relationship with computers and technology in general, more natural and easier to learn.

However, the benefits of technology do not reach all social groups. The elderly show some resistance in adopting technology, making them deprived from the benefits it has to offer. This problem is gaining more importance, since due to our healthy lifestyles we live longer, and are likely to be physically, socially and cognitively active until older ages.

E-mail address: elvio.rodrigues@ist.utl.pt (Élvio Rodrigues), micaelcarreira@ist.utl.pt (Micael Carreira), daniel.goncalves@vimmi.inesc.pt (Daniel Gonçalves)

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By captivating the interest of elder users in technology, we can fight isolation and exclusion and allow the elderly to be more productive, independent and to have a more social and fulfilling life. This can be done by improving the accessibility to existing devices and services. All this should be made possible at peoples homes, since elderly people have sometimes some level of impairments caused by age, which reduces their mobility.

In this study we will survey several HCI methods and control interfaces, evaluating the feasibility of different solutions, considering both physical and situational impairments of elder users. After concluding that multi-touch and body gestures interfaces are best suited for the elderly, we will describe the preliminary work we have been developing.

The multi-touch technology lack the haptic feedback of physical buttons, making it harder to accurately select targets. This characteristic particularly hampers certain tasks, such as text-entry, where the user has to constantly select one of many small targets. Therefore, our aim is to perform a series of studies to better understand touch behavior of both younger and older adults when typing. We developed 5 QWERTY keyboard variants which aim to improve typing speed and reduce the error rate, and afterwards performed an experimental evaluation. Then, we systematically analyze the performance of each variant.

As for the body gestures interface, we depict some preliminary work we have been developing. Usually, users interact with motion sensing devices by actively performing recognizable gestures, wich is the main purpose of these devices. However, we also explore other capabilities of the motion sensing devices, related with a more passive way of interaction. We developed features that allow to sense the user and ambient – user attention detection, user recognition and privacy management. These features still remain untested, but will be subject to experimental evaluation in the near future.

2. Related Work

The elderly show some resistance in adopting technology, making them deprived from the benefits it has to offer. Several studies were performed in order to perceive the most suitable interfaces for this age group. In this chapter, we will depict some of the most frequently used interaction interfaces nowadays, analyzing studies that focus on the usability of these interfaces for elderly users.

2.1. *Traditional Interfaces*

Nowadays, the keyboard and mouse are the most common setup to operate a desktop computer, despite the availability of alternative input devices.

In a study conducted by Kevan et al.[10], they aimed to determine whether computers can be helpful to elderly persons residing in a long-term care facility, by teaching them how to perform basic tasks on the computer. In the beginning, the elders were participating enthusiastically, but then they progressively stopped attending classes until the authors decided to stop lecturing. They concluded that the computers were not designed for operation by frail individuals and persons with physical or mild cognitive impairments. A similar result was achieved in a previous study[3], where the authors concluded that computer anxiety, computer efficacy, and attitude toward aging were significantly related to staying in the program.

Indeed, the primary instrument to manipulate the computer, the mouse, is not properly suited for the elderly. A study by Chaparro et al.[2] suggests that the aging population (particularly men) may face greater difficulty using an input device that relies on motions of the wrist, since they have a limited range of motion. The use of other pointing devices, such as a trackball, can mitigate some of the problems elders experience with the mouse. For people with low strength, poor coordination, wrist pain, or limited ranges of motion, rolling a trackball can be easier than shuttling a mouse across the surface of a desk[15].

As we have seen in different studies, the traditional interfaces are not easy to use for novice users, particularly when they are elderly. The hardware, software and technological characteristics of this technology make it unnatural, requiring a learning and adaptation process in order to use this interface. The fact that the elderly's cognitive skills often deteriorate, affecting their memory and learning, makes their capability to learn traditional interfaces rather reduced.

2.2. Multi-touch Interfaces

Multi-touch interfaces use a touch sensing surface to recognize the presence of one or more points of contact. This kind of technology gained popularity on mobile devices, such as tablets and smartphones. Since touch screens allow users to directly interact by touching with the information displayed on the screen, this technology is considered to be one of the most natural of all technologies[6].

However, considering the elderly deteriorated capabilities (degraded vision and tactile sense), this kind of interfaces should have some specific features like multiple sizes for fonts, buttons and icons, as pointed out by Stone[12]. The author verified that one of the main problems of mobile touch devices among elderly, is that buttons are too small. But since the button size and arrangement is under software control, it is possible to easily circumvent that problem. Murata et al.[9] argues that, in comparison with a traditional mouse and keyboard setup, the touch interface has the advantage of simplicity and offers opportunities to design more accessible systems.

In a study conducted by Werner et al.[14], he selected 11 seniors with no previous internet or PC experience and evaluated the general usability and acceptance of a selected tablet. The results of the study show high acceptance and satisfaction rates among the user group and hence suggest a future focus on the development of tablet based applications for seniors. The authors argue that tablets are an easy way to step into the digital world.

Loureiro et al.[8] analysed different aspects of 8 touch-based tabletop interfaces for the elderly. In all surveyed works, they concluded that touch yield a natural, direct, and intuitive way of interaction with a device allowing easier human-computer interaction for elder users. In every surveyed work, they found that the required computer literacy from the users is very low. Indeed, people with low or no computer literacy found using touch screens easy and motivating.

2.3. Gesture Interfaces

Gesture recognition can be seen as a way for computers to understand human body language, interpreting those gestures via mathematical algorithms. There are mainly two ways of achieving gesture recognition: with devices that have motion sensing capability (e.g. accelerometer, gyroscope, magnetometer) or video capturing and processing - also called computer vision - to detect users movements. Gesture recognition is one of the most natural and intuitive ways of interacting, since it closely mimics how humans interact with each other.

Gesture recognition interfaces emerged recently and gained popularity in the video game industry. Therefore, most studies evaluating body gestures interfaces fall on the scope of games. Jung et al.[7], examined the impact of playing Nintendo Wii games on the psychological and physical well-being of seniors in a long-term care facility. Although the interface and the game itself were not specifically adapted to elder users, the elderly adapted well. Results showed that the elderly found this kind of games stimulating, and showed interest in participating in this kind of activities again. Also, a substantial amount of physical activity was required to play, which is likely to be beneficial in the health of the elderly.

Hassani et al.[16] developed an assistive robot which helps elderly people perform physical exercises. The elderly were required to perform a body gesture in order to skip to the next exercise. The score of this interface in measures of effort, ease, anxiety, performance and attitude was very high. Participants were very positive about the use of gestures. Although the tested interaction was really simple, this study showed that the elderly find gesture interfaces an easy way to interact with technology.

3. Multimodal Interfaces

As depicted previously, the main reason elderly people don't use technology on a regular basis is because they aren't completely adapted to the currently available solutions for Human-Computer Interaction (HCI). By captivating the interest of elder users in technology, we can fight isolation and exclusion and to allow the elderly to be more productive, independent and to have a more social and fulfilling life.

In the related work, we have seen that the multi-touch and body gesture interaction modalities are preferred by the elderly users over the traditional ones. Since both interfaces are adequate, we can combine them to create a more complete multimodal interaction interface. By combining multiple interfaces modalities, the weaknesses of one modality are counterbalanced by the strengths of another, resulting in an increased usability and accessibility.

Since this study regards ongoing work, we are still focusing on the development and usage of each individual modality. In the future, we will combine both modalities, thus creating a multimodal interaction. Each interaction modality will work synergistically with the other, resulting in richer interaction scenarios.

4. Ongoing Research on Touch Modality

We decided to focus our study on a particularly difficult task to perform in a multi-touch interface: text-entry. The lack of haptic feedback makes it harder for users to accurately select the desired key. To improve user efficiency when performing this task, we developed 5 QWERTY keyboard variants, which we depict in this chapter. We hypothesize that older users with mild cognitive problems will benefit from the *Color* variant, because it highlights the next four most probable keys. We also believe that older users with motor-impairments will benefit from the *Shifted* and *Size Invisible* variants, because these variants will compensate the deviated touch patterns of users and tolerate touch points further away from the highlighted key, respectively. Then, we describe the performed experimental evaluation and finally, we systematically analyze the performance of each variant.

4.1. Text Prediction

In order to develop more advanced variants of the virtual QWERTY keyboard, we used two types of prediction to anticipate what the user is going to write: *word prediction* and *next letter prediction*. If the *prediction system* is able to guess correctly, the number of keystrokes needed to write a sentence decreases. This way, it can enhance the speed of writing and reduce the required physical effort to compose messages.

There are several techniques to predict the text the user is trying to input, some more complex than others. However, by increasing the complexity of the predictions systems, the prediction results only increase marginally[4]. This way, and since the aim of this study was not developing a novel and more efficient prediction algorithm, we opted for a simplistic one. Our predictor only takes word frequencies into account and, when the user writes the beginning of a word, the system offers the most probable words beginning with the same character(s).

To implement the *word prediction system*, we used the CETEMPúblico Portuguese text corpus[1], which contains approximately 180 million words. From that corpus we processed the word frequencies and then stored it in a dictionary structure that contains all the information about each word and its prefixes frequencies, so that the information can be efficiently accessed. After implementing the *word prediction system*, we decided that the *next letter prediction* should be based on the same algorithm. This is because, if later on we decide to merge variants that use different types of prediction, it is important that both predictions are consistent.

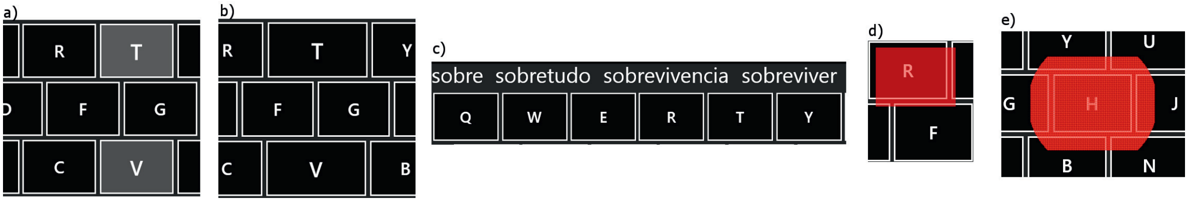

Fig. 1. (a) Color variant; (b) Width variant; (c) Predicted words variant; (d) Shifted variant; (e) Size invisible variant.

4.2. Implemented QWERTY variants

As we stated previously, text entry on touch devices remains slower and more error-prone than on traditional computer keyboards. This way, we decided to implement different alternatives for the traditional virtual QWERTY

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[1] http://www.linguateca.pt/cetempublico/

keyboard, with the aim of allowing users to input text faster and with fewer errors. Taking this into account, after developing the regular QWERTY keyboard to serve as a baseline, we developed 5 variants, which are described in the following subsections. All the variants show visual feedback on the pressed key, by inverting its color.

4.2.1. Color variant

The *Color* keyboard variant uses the developed *letter prediction algorithm* to highlight the next most likely letters for the current word. We expect this variant to perform better than the regular QWERTY keyboard, especially if the user is not acquainted with the QWERTY layout, which might be the case of most older adults. We also expect that users commit fewer errors by noticing if they are pressing a key that is not highlighted, or by acknowledging they missed or omitted a key press.

Regarding the number of keys to highlight, we decided to highlight four keys, since a previous study [1] concluded that it was the optimum number between one, two and four keys. The highlighted key changes its color from black to grey to avoid the cultural connotations that are associated with particular colors (e.g.: the green and red colors have positive and negative connotations, respectively). We also increase the size of the button's label. The highlight is continuous: the more probable the letter, the brighter the color and bigger the label of the button.

4.2.2. Width variant

The *Width* variant uses the same principle as the *Color* variant. The difference is that it highlights the 4 most probable keys by increasing their width by 30% (Figure 1b). Similarly to the *Color* variant, the label of the button (the letter in the button itself) increases in size proportionally to its probability.

With this variant we expect the users to commit less substitution errors by hitting the desired key instead of the neighbor keys, since the most likely keys are bigger. Also, we expect users to notice if they are pressing a letter that is not highlighted, and thus commit fewer errors. A previous study [1] has shown that this approach can both improve the speed and reduce errors of the typed sentences in smartphones.

4.2.3. Predict words variant

This variant is a common alternative that can be selected as typing method in most of touch devices. While the user is typing, a list of the most likely words is shown in a horizontal ribbon above the keyboard (Figure 1c). If the word the user wants to write is on the suggested list, he can save some key touches by tapping it so the full word along with a space character will be inserted.

While this solution is fairly popular within younger users, we are not sure if it will be adequate for older users. Since there is a cognitive effort required to process the list of suggested words, it might be harder for this group of users to divide their attention between the actual typing and the scanning of the suggestions' list. In our first prototype we opted to suggest 4 words, but we still have to validate this decision with the older adults.

4.2.4. Shifted variant

The approach of shifting the real touch area of keys from its visual representation was inspired by the work of Nicolau et al[11]. He found a clear predominance of right and bottom key substitutions in the data, which suggests that participants frequently hit in the right-bottom side of targets. Taking this into account, we implemented a variant that deviates the real touch area of each key 10% of the key's height to the bottom, and 10% of the key's width to the right (Figure 1d). Our goal is to test if there is indeed a tendency to hit the keys in the right-bottom direction, and assess what is the optimum deviation we must apply to help users commit less neighbor substitution errors. Note that visually for the user, this variant is exactly the same as QWERTY.

4.2.5. Size Invisible variant

Similar to the *Width* variant already described in section 4.2.2, this variant also increases the size of the most likely keys. However, this variant does it only internally; to the users it remains visually the same as a regular QWERTY keyboard. This approach has also been the aim of previous studies[5].

In our implementation, we increased the likely keys' width in 50% (25% to the left and 25% to the right) and 50% in height. We also imposed the condition of a maximum distance to the center of the key of 125% the diagonal radius of the key, so the final touch area of a likely key have rounded corners (Figure 1e). If two adjacent keys are highlighted and a touch occurs in an ambiguous area, the original boundaries of keys are preserved. With this variant we expect users to commit less substitution errors by hitting the desired key instead of the neighbor keys, since the most likely keys are internally bigger. We also expect this variant to be more adequate for the older adults when compared with the *Width* variant, since this one does not visually change the layout of the keyboard.

4.3. User tests

In a first phase, we performed the user tests with 20 younger adults. The results we achieved allowed us to improve the most promising variants, as well as rule out the variants with least potential. At this point, we have only performed a test with one elderly user. We are aware that 1 older adult is insufficient to draw conclusions, so it must be regarded as a very preliminary test with preliminary results. In the near future, we will be performing the remaining 19 tests with older adults. Since the procedure of the test was very similar to both user groups, we will describe it in this section and point out the differences when relevant.

4.3.1. Procedure

At the beginning of each test, we explained the participant that the aim of the test was to evaluate each variant of the virtual QWERTY keyboard, and not the users themselves. The users were free to choose how they wanted to type: with one or two hands, with the tablet supported on the table, on the lap or on the free hand.

The test consisted in copying a sentence that was displayed on top of the screen, one at a time, and then move to the next sentence. Both required and transcribed sentences were always visible. In order to avoid different correction strategies by the users, the delete key was removed, so users were not allowed correct errors. Participants were instructed to continue typing if an error occurred.

Before the evaluation, young users were allowed to try each keyboard variant for two minutes so they could familiarize themselves with the several variants. Older adults were allowed to try each keyboard variant for four minutes. The participants were only allowed to try the variants that had visual changes. Therefore, users were not aware of the *Shifted* and the *Size Invisible* variants, so the results would be unbiased.

On the evaluation phase, participants were instructed to type the sentences as quickly and as accurately as possible. Each user was asked to insert 5 sentences, where the first was still a trial and would not count to the results. In the end, users were asked to answer a survey with some demographic data, as well as their satisfaction regarding each variant. The whole process took about 30 minutes per young user, and 45 minutes per older user.

4.3.2. Apparatus

A Samsung ATIV Smart Pc Pro was used in the studies. Each key had 2 cm of width and 1.5 cm of height. Visually, there is a space of 0.2 cm between keys, horizontally and vertically. However, our implementation does not allow pressing between keys – each touch is always assigned to a key. All participants' actions were logged through our evaluation application, so posterior analysis could be performed.

4.4. Results with the young users group

While the users were performing the tests, data regarding the touch positions and time was automatically recorded. This allowed us to calculate the typing speed (WPM) for each variant as well as the error rate.

4.4.1. Typing Speed

Results show that there are significant differences between QWERTY and *Color*, *Width* and *Predict Words* variants, meaning that users type significantly slower in these 3 variants (F(5, 90) = 18.787, p ¡ 0.001). As expected, there were no significant differences between the typing speed of the traditional QWERTY and the *Shifted* and the *Size Invisible* variants.

Regarding young users, this result was somewhat expected for the *Color* and *Width* variants, since the visual changes can be distracting, which may reduce the typing speed. The *Predict Words* variant is also slower than the traditional QWERTY, which indicates that the saved keystrokes does not make up for the time and cognitive effort required to constantly check the suggestions list. Having said that, we expect these variants to help older users improve speed, since most of them might not be acquainted with the QWERTY layout. Therefore, if the *prediction system* suggests the right letter, the user will not need to waste time scanning all the keys.

4.4.2. Error Rate

To calculate the errors introduced by users in each variant, we used the Levenshtein distance between the typed and the expected sentence. All variants slightly improved the overall quality of the typed sentences, since the error average was highest on QWERTY. Still, as a Friedman test revealed a p-value ¿ 0.05, these improvements were not statistically significant.

However, these results regard all types of errors. But, the *Shifted* and *Size Invisible* variants only aim to correct the neighbor substitution errors. So, if we focus in this type of error, the *Shifted* and *Size Invisible* variants were actually able to correct 48.65% and 62.96% of the substitution errors, respectively. It is important to note that these values were only achieved after finding the optimum vertical/horizontal shift for the *Shifted* variant and the optimum size increase for the *Size Invisible* variant. The optimizations were found by selecting the value that maximizes corrections and minimizes erroneous interventions. Before the tests we set these values empirically, so at that point it had only corrected 13.51% and 37.04% of the substitution errors, for the *Shifted* and *Size Invisible* variants, respectively.

Even though the *Shifted* variant was able to correct 48.65% of the substitution errors in the optimized version, we did not verify the bottom-right touch pattern within this group. In average, there is an overall tendency to touch on the bottom-right side of the keys in the left side of the keyboard, and to touch on the bottom-left side of the keys in the right half of the keyboard. But, when analyzing the average deviation from the center of the key of each user, we found that this deviation is strongly user-dependent.

Despite none of the variants we developed showed significant improvements regarding the error rate, we performed a t-test between the QWERTY and the *Color* variant, since this was the variant with least errors. The t-test confirmed that there is a significant difference between these variants regarding error rate (t(17) = 3.151, p = 0.006). This means that, despite all the users were already familiarized with the QWERTY layout, they were committing less errors with this variant, especially omission errors.

Omissions are most likely to occur when users miss a key or when their finger slips (they press one key and release on another, generating no output). We noted that this type of error is most frequent with the space key (47% of all the omissions are spaces, in QWERTY). It happens because this key is on the bottom of the touch screen, and sometimes users completely miss the touch area captured by the tablet, hitting its bevel instead. For those cases when users missed the space bar, they were able to detect it on the *Color* variant because the space bar remained highlighted, indicating that the key was not correctly pressed. As a matter of fact, in the *Color* variant, the space omissions were lowered to only 33% of all omissions.

4.4.3. User satisfaction

In general, users were satisfied and found the QWERTY, *Color* and *Predict Words* variants easy to use. Users said the *Width* variant was difficult to use and were not happy using it. When comparing each variant to QWERTY, users said that, on average, the *Color* and *Predict Words* variants were useful. The *Width* variant obtained very disperse results in this question. However, the average answered that is was somewhat unhelpful.

Regarding the cognitive effort required to use the several variants, QWERTY was rated as the less demanding. The *Color* and *Predict Words* variants were also considered to require low cognitive effort, being the former a little less demanding. The *Width* variant was the one that required more cognitive effort. When asked about the easiness of finding a particular letter, users found it easy in QWERTY and *Color* variants, and both variants averaged the same. The *Width* variant had the worst results again; users said it was relatively difficult to find a particular letter.

In general, the QWERTY averaged better than other variants in satisfaction and easiness to use, which indicates that the users prefer a visually static keyboard, as similar as possible to the physical ones.

4.5. Very Preliminary results with old users

The results of the tests with the young adults group allowed us to filter some of the least promising variants. We decided to discard the *Width* variant, since it was the one with worse user satisfaction results. Even though the preferences between user groups can vary, we feel pretty confident that older users would not adapt to a layout of the keyboard that is frequently changing. We also rulled out the *Shifted* variant because a pattern was not found in the previous tests, and we can still use the touch inputs of other variants to check if the touch patterns follow the right-bottom deviation described by Nicolau et al[11]. This way, by testing less variants, we also avoid asking such a great effort from the elderly, since they are certainly slower than younger users.

Only one older user got through the whole test, so we will base this section in what we observed during that test. A second user tried some of the variants, but then reported that she was out of time and left after a while. We believe that this was also partially because she was performing an intense cognitive effort, and was afraid of not performing so well as the previous senior.

The senior that performed the test had some experience with typewriters, although he had not used them for some years. He was 84 years old, and he opted to type with the tablet on the table, using both forefingers to type.

During the test we observed a few details that were also pointed out by Nicolau et al[11]. Although it was not that frequent, the user made three insertion errors that Nicolau classified as *bounce insertion error*, which happens when a key is unnintentionally pressed more than once, producing unwanted characters. The three errors took place in different keys (space, i and e), but the pattern is the same – the user wanted to insert only one of the aforementioned characters, but ended up inserting two in total (i.e. double space, double i and double e). The solution to this kind of insertion error is to only accept key presses that have inter-key interval higher than a certain threshold. If the interval is lower than the threshold, the key press is considered an insertion and is therefore discarded. Still, we will only be able to explore this threshold after performing the tests with the remaining older adults.

Something that was also pointed out by Nicolau et al.[11] was that users sometimes forget to type the intended characters or misunderstand the required sentence. This happened several times even though we only performed one complete test. The second user (the one that did not complete the whole test) got lost several times, sometimes rewriting the same word she had already written. We also verified that similar and symmetrical letters result in cognitive errors, which is the case of the ”p” and ”q” letters. Since the keys are far away from each other on the keyboard, it must be a cognitive error.

Overall, the user was satisfied with the use of a virtual keyboard, despite being the first time he experimented a tablet device. He said his favorite keyboard was the traditional QWERTY, since it was the one that looked more like the one he was used to. Still, he said that the *Color* variant could be a good option, if he had the chance to use it a little bit more. The user felt that the *Predict Words* variant was difficult to use, in the sense that he needed to divide his attention between the word he was writing and checking if the word we wanted to write was in the suggested list. He tried it briefly during the training phase, because we encouraged him to. However, in the evaluation phase, the user kept writing without paying much attention to the suggested words and never accepted a word from the suggested list.

5. Ongoing Research on Gesture Modality

As we have previously seen, the elderly adapt well to the gesture modality, finding it easy to use. As a matter of fact, it represents a natural and intuitive way of interacting, since it closely mimics how humans interact with each other. However, the degraded motor skills of the elderly may be a hindrance when using this modality.

To overcome this difficulty, the defined gestures must take the elderly's physical limitations into account. Gestures that require fast movement, are too rough, or require complex positions or movements, should be avoided. Also, we must state that the extensive use of this interface may cause fatigue, especially when the users are seniors.

The dimensionality of gesture interfaces is related to the number of gestures defined, usually being each gesture associated with a particular command. Nowadays it is possible to recognize a fair amount of gestures, with reasonable accuracy. Nevertheless, the gestures interface are not suited to perform particular tasks (e.g.: text entry), and this may be the main reason why gestures are not yet a standalone way of interacting with computers.

With this limitations in mind, we developed some features we found interesting for a gesture interface. We considered a usage scenario where the elderly users are comfortably sitted in their living rooms, interacting with a computer that is connected to their television through gestures. We used a Microsoft's Kinect device for the gesture recognition.

5.1. Active Interaction - Gestures Detection

As we already stated, the defined gestures must take the elderly's physical limitations into account. Therefore, we currently only have one implemented gesture: the horizontal swipe. This is a natural gesture and physically easy to perform. It works pretty good for some recurrent tasks, such as scrolling. We opted for the horizontal swipe instead of the vertical variant, because when the user has his hands in the rest position, it is impossible to perform a downward swipe before performing an upward one.

The gestures performed by users are detected by constantly tracking the users' hands' positions. We developed a configurable gesture detector, which allows to easily change the minimal and maximal length of the gestures, as well as minimal and maximal duration. To prevent false positives, a minimal period between gestures can also be set. An experimental evaluation of this gesture with elderly users is still lacking, which will allow us to derive the optimal parameterization for our swipe gesture recognizer.

We also deliberated about using the hand motion to control the computer's screen cursor. However, we found that having the arm forwardly stretched was a quickly tiring exercise, even for young users. Therefore, an alternative gesture, better suited for the elderly, should be developed and tested in an experimental evaluation.

5.2. Passive Interaction - User Recognition, Attention Tracking and Privacy Management

The Kinect camera can also be used as a form of passive interaction, by detecting the user and the surrounding ambient. We developed a face recognition module through the use of Kinect's color camera image. This way, when a user enters in the area captured by the Kinect, he can be automatically identified without the need of usernames or passwords. The implementation uses the Eigen Faces and Principle Component Analysis (PCA)[13] to recognize the users faces. It is possible to customize the face recognition threshold level, which allows balancing between accuracy and successful recognitions. If the threshold is lower, the face recognizer will be more accurate, but there will be more times when a user can't be recognized. If it is higher, it will recognize users more often, but with less accuracy.

We also implemented a module that detects the motion on the environment. This module works as a privacy manager, allowing to quickly hide private information when someone comes nearby. The motion detection algorithm excludes the pixels of the current user, thus avoiding false positives when the user performs a gesture or simply moves around. This module was also implemented through the use of Kinect's color camera image, by comparing the current frame with the previous one. Some image transformations (such as grayscale, pixelate and dilatation filters) are applied in order to disregard the noise generated by the cameras. If the amount of changed pixels surpasses a configurable threshold, a motion detection event is fired.

Finally, we developed a module that tracks if the user is paying attention to the system. By using the Microsoft's Face Tracking SDK, we developed an algorithm that detects when the user is looking at the screen, allowing the system to perceive if users are paying attention and then act accordingly. This allows interaction scenarios such as pause media playing as the users turns his face to talk to someone, and then resume playing when the user looks at the screen again.

The features we described still lack of formal experimental evaluation, but we are planning to perform it in order to understand their suitability for elderly users and optimize each module.

6. Conclusion

In this paper we succinctly analysed the suitability of several interaction interfaces for the elderly users. We hypothesize that combining several interfaces will bring additional value to the users, since the weaknesses of one modality can be counterbalanced by the strengths of another, resulting in an increased usability and accessibility. We then described the preliminary work we have been developing on the multi-touch and gestures interaction modalities.

Regarding the touch modality, we focused on text-entry tasks. We developed and evaluated a virtual QWERTY keyboard and 5 variants for tablet devices, with the aim of improving the typing speed and reducing the error rate. However, we were not able to improve typing speed; users were able to type faster in the traditional QWERTY keyboard. The fact that some variants introduce visual changes may be distracting for users, slowing down their typing. Results also showed that the *Predict Words* variant is also slower than the traditional QWERTY. We assume this is because users have to divide their attention between typing and checking if the desired word is on the suggested words. As it was expected, no significant differences were found between traditional QWERTY and *Shifted* and *Size Invisible* variants, since both these variants remain visually static.

Regarding error rates, neither *Shifted* nor *Size Invisible* variants were able to reduce errors significantly. Still, both variants are solely focused on reducing neighbor substitution errors, which they corrected 48.65% and 62.96%, respectively. The *Color* variant had a significantly lower error rate, at the cost of also reducing typing speed. The *Width* and *Predict Words* variants had similar error rates when compared to the traditional QWERTY keyboard.

The preliminary evaluation we performed with the young users group allowed us to rule out the least promising variants (*Shifted* and the *Width* variants), which enabled us to make the tests more simple and feasible for the elderly. Regarding the *Shifted* variant, a strongly user dependent touch pattern was found. Therefore, a good solution may be to continuously adapt the centroids of the keys, for each particular user. However this solution requires extensive tests, which we are not able to perform with elderly users. The *Width* was reported to be very difficult and confusing to use; users were not happy using it. This problem would be aggravated for the elderly users, which have more difficulties in interacting with technology.

We also depicted the ongoing work regarding the body gestures modality. We developed both active and passive ways of interacting with this modality, which can improve the automaticity of a system. However, this is still a work in progress, as experimental evaluation of the developed work with older users is still pending, both for the gesture and the touch interfaces.

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