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EDITORS' LETTER

This volume 2, number 1 of the Journal of Accessibility and Design for All comprises a selection of papers presented at the IV International Congress on Design, Research Networks, and Technology for all held in Madrid, June, 27 - 29, 2011. This congress is promoted by the ONCE Foundation *for cooperation and social inclusion of persons with disabilities* and intends to monitor the progress of assistive technologies for people with disabilities. Therefore, papers here presented cover different areas related to learning, health, communication and social life, which are also in line with the philosophy of the journal and complement some of the five research areas of this journal.

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IMPROVING THE ACCESSIBILITY AT HOME: IMPLEMENTATION OF A DOMOTIC APPLICATION USING A P300-BASED BRAIN COMPUTER INTERFACE SYSTEM

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Abstract: The aim of this study was to develop a Brain Computer Interface (BCI) application to control domotic devices usually present at home. Previous studies have shown that people with severe disabilities, both physical and cognitive ones, do not achieve high accuracy results using motor imagery-based BCIs. To overcome this limitation, we propose the implementation of a BCI application using P300 evoked potentials, because neither extensive training nor extremely high concentration level are required for this kind of BCIs. The implemented BCI application allows to control several devices as TV, DVD player, mini Hi-Fi system, multimedia hard drive, telephone, heater, fan and lights. Our aim is that potential users, i.e. people with severe disabilities, are able to achieve high accuracy. Therefore, this domotic BCI application is useful to increase their personal autonomy and independence, improving their quality of life.

Keywords: disability; brain-computer interface; domotics.

Introduction

A Brain-Computer Interface (BCI) is a communication system that monitors the brain activity and translates specific signal features that reflect the user's intent into commands that operate a device [1]. The method most commonly used for monitoring the brain activity in BCI systems is the electroencephalography (EEG). The EEG is a non-invasive method that requires relatively simple and inexpensive equipment and it is easier to use than other methods [2], such us magnetoencephalography (MEG) or positron emission tomography (PET).

BCI systems can be classified into two groups according to the nature of the input signals. Endogenous BCIs depend on the user's control of endogenic electrophysiological activity, such as amplitude in a specific frequency band of EEG recorded over a specific cortical area [2]. BCIs based on sensorimotor rhythms or slow cortical potentials (SCP) are endogenous systems and often require extensive training. Other systems depend on exogenous electrophysiological activity evoked by specific stimuli and they do not require extensive training [2]. BCIs based on P300 potentials or visual evoked potentials (VEP) are exogenous systems.

This preliminary study proposes the implementation of a BCI application to allow disabled people to interact with the devices present at their usual environment. Thus, the application will increase their autonomy and independence at home. The proposed BCI application uses the P300 evoked potentials as control signal. In previous studies [3, 4] a domotic application was implemented using a motor imagery-based BCI system. Potential users of this kind of systems evaluated the application. People with severe disabilities, both physical and cognitive ones, from a disability and dependence reference center located in León (Spain) participated in the study. Our results showed that subjects had severe difficulties to achieve high accuracy moving the cursor to the desired targets. Probably, it was due to their cognitive problems. Motor imagery-based BCI systems require an extensive training period and subjects need a very high level of concentration. Users have to pay complete attention to the motor imagery mental tasks necessaries to move the cursor. To overcome this limitation, the present preliminary study proposes the implementation of a domotic control application using a P300-based BCI system. These systems do not require extensive training. Thus, the domotic application probably is easier to control for people with severe disabilities. In a BCI system based on P300 evoked potentials, a visual stimulus evokes characteristic electrophysiological activity. It is also called the 'oddball' paradigm [2]. Many visual stimuli are presented to the subject but only one is related to the option he wants to select. Thus, this specific stimulus evokes a potential peak, approximately 300 ms after the stimulus, called P300 evoked potential. Analyzing for what stimulus appeared the P300 potential it is possible to know what is the desired option.

Recently, several studies have analyzed the performance of P300-based BCIs with disabled people. Nijboer et al. reported a mean accuracy of 79% working with four subjects disabled by amyotrophic lateral sclerosis (ALS) [5]. In the study of Hoffman et al., five disabled subjects with different pathologies (cerebral palsy, multiple sclerosis, ALS, traumatic brain and spinal-cord injury, and post-anoxic encephalopathy) participated [6]. Four of them were able to achieve 100% accuracy after 12 blocks of stimuli presentations. However, the other disabled subject could not obtain classification accuracies above chance level [6].

P300-based BCI systems were initially used to select letters and allow subjects to communicate with other people. Recently, other applications using P300 potentials have been proposed: browsing the Internet [7], publishing messages in the Twitter social network, controlling the movement of a wheelchair [8] or teleoperating a robot [9].

Our domotic application allows the user to control several devices usually present at home: a TV set, a DVD player, a mini Hi-Fi system, a multimedia hard drive, a telephone, the lights of a room and the heating and ventilating devices. Thus, the users can interact more easily with their common environment, increasing their independence, personal autonomy and accessibility.

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This communication is organized as follows: Section 2 introduces the P300 response bases. In Section 3, EEG recording details are presented. Section 4 describes the domotic BCI application design and in Section 5, the resultant application is shown. Finally, Section 6 contains a discussion of the preliminary results. It also includes the main conclusions and the proposed future work.

The 'Oddball' Paradigm and the P300-based BCI systems

A P300-based BCI has an apparent advantage. It requires no initial user training: P300 is a typical, or naive, response to a desired choice [2]. At the same time, P300 and related potentials change in response to conditioning protocols, and it is also likely they change over time and with the subjects' age [2, 10, 11].

Infrequent or particularly significant auditory, visual or somatosensory stimuli, when interspersed with frequent or routine stimuli, typically evoke in the EEG over parietal cortex a positive peak at about 300 ms [2, 12]. Thus, BCIs based on P300 evoked potentials are exogenous systems since they depend on exogenic electrophysiological activity evoked by specific stimuli. This P300 or oddball response has been used in BCI systems [2, 7, 8, 9, 13, 14].

The user faces a 6 x 6 matrix of letters, numbers and/or other characters [13]. Every 125 ms, a single row or column flashes. The rows and the columns are intensified in a random sequence in such a manner that all 6 rows and 6 columns were intensified before any was repeated [13]. Thus, in a complete trial of 12 (6 rows + 6 columns) flashes, each character flashes twice. The user makes a selection by counting how many times the row or column containing the desired choice flashes [2, 13]. Usually, EEG over parietal and occipital cortex is recorded, the average response to each row and column is computed and P300 amplitude for each possible choice is obtained. The P300 potential is prominent only in the responses elicited by the desired choice, and the BCI uses this effect to determine the user's intent [2].

In online experiments and offline simulations, a variety of different algorithms for recognizing the desired choice have been evaluated, and the relationship between the number of trials per selection and BCI accuracy has been described [2, 13]. These analyses suggest that the current P300-based BCI could yield a communication rate of one word (i.e. 5 letters) per minute and also suggest that considerable further improvement in speed should be possible. In people with visual impairments, auditory or tactile stimuli might be used [10].

EEG Recordings

A g.USBamp biosignal amplifier (g.tec, Austria) of 16 monopolar channels is used to record the subjects' EEG activity. The EEG channels are recorded monopolarly with the left ear serving as reference and the right ear as ground. Signals are sampled at 256 Hz, bandpass-filtered between 0.1 and 60 Hz and Notch-filtered at 50 Hz. Impedances are kept below 5 kΩ. Eight EEG channels are recorded: Fz, Cz, CP3, CP4, Pz, PO3, PO4 and Oz, according to the modified international 10–20 system [15]. This group of channels is selected because it is able to detect the proper P300 response around Cz and also other evoked potentials elicited by visual stimuli over the visual cortex [16]. A Common Average Reference (CAR) spatial filter is used to maximize the Signal to Noise ratio (SNR) [17].

The users start performing a calibration session. They have to select a fixed sequence of buttons from the matrix shown on the screen. The EEG activity related to the calibration session is then analyzed offline to detect the specific instants and channels where the P300 response and the other visual evoked potentials are more explicit and, therefore, easier to detect. To that purpose, we use the 'P300 Classifier' tool included in the BCI2000 general-purpose system [18]. This tool uses a Stepwise Linear Discriminant Analysis (SWLDA) [13, 14, 18] to select the best features for each subject. An LDA classifier is developed using these features. Once the classifier is defined, the domotic application can be used to control the environment.

Domotic Application Design

Digital homes are considered as accessibility tools, improving personal autonomy and quality of life by making easier the access to devices present at home. However, people with severe motor disabilities need a special interface to access these devices. BCI systems could be really useful for these people to control the devices present at their usual environment.

Our application will take into account the more common needs of disabled people: comfort (control of temperature, lights, etc.), communication (telephone) and entertainment (TV, DVD player, multimedia devices, etc.). Making easier the access to this kind of devices, disabled people will be able to perform by themselves common daily activities.

To implement the domotic application the BCI2000 general-purpose system will be used [18]. A friendly interface will be programmed in C++ language to show the different control options to the users. Thus, they will be able to navigate through different menus and access to most of the devices' functionalities. As the proposed devices are controlled by infrared (IR) signals, an IR emitter device will be used to send the commands to the TV, the DVD player, the telephone, etc.

After the calibration session, in the following sessions the users have to select a sequence of buttons previously proposed. For each button, if the BCI system selects the correct one, i.e. the proposed button, this trial counts as a hit, otherwise as a miss. Thus, it is possible to assess the accuracy as the percentage of hits to the sum of hits and misses. The SWLDA classifier indentifies the suitable discriminant function by adding spatiotemporal features (i.e., the amplitude valued at a particular channel location and time sample) to a linear equation based on the features that demonstrate the greatest unique variance [5]. In the initial experiments at our laboratory, a healthy person is able to achieve 90% accuracy after 15 blocks of stimuli presentations.

Results

Our application has been designed taking into account the needs of its potential users: people with severe disabilities. Our aim is that disabled people test and evaluate the BCI application. Users from the National Reference Center (CRE) of Disability and Dependence located in San Andrés del Rabanedo (León, Spain) will test the application.

The application is based on the P300 response to infrequent stimuli. It allows to control several devices related to domestic, comfort, communication and entertainment needs. Our application controls the following devices and their main functionalities:

- *TV:* switching on/off; volume control: turning up/down or muting; channel selection: up/down or selection from 0 to 9; menu configuration: accessing/exiting the menu, enter, right, left, up and down; accessing the teletext; and coming back to the main menu.
- *DVD player*: switching on/off; playing, pausing, stopping, going to the next or previous films or photos; exploring the DVD's contains: menu, list, up, down and enter options; muting the volume; and coming back to the main menu.
- *Hi-Fi* system: switching on/off; volume control: turning up/down or muting; radio or CD function selection; reproduction options: play/pause and stop; next or previous track or radio station selection; and coming back to the main menu.
- *Multimedia hard drive*: switching on/off; exploring the hard drive's contains: menu, up, down, right, left and enter; playing, pausing, stopping, going to the next or previous films, audio files, photos, etc; showing/hiding the subtitles; and coming back to the main menu.
- *Phone*: picking up and putting down the phone; dialing a phone number: selecting from 0-9; making a phone call; accessing the contacts list; dialing a memorized phone number; and coming back to the main menu.

- *Lights*: switching on/off; changing the light color: white, red, blue, green, orange or purple; turning up/down the intensity; flashing mode; and coming back to the main menu.
- *Heating*: switching on/off; turning up/down the intensity; programming the sleep function, from 30 min to 4h; activating/deactivating the swing mode; and coming back to the main menu.
- *Ventilating*: switching on/off; increasing or decreasing the speed; programming the sleep function; activating/deactivating the swing mode; activating/deactivating the desired ventilators; and coming back to the main menu.

The domotic application shows the user the main menu on the screen. The main menu consists on a 3 x 4 matrix of images that depict a specific action or device. It includes the devices previously specified and some control commands as stop, pause or resume the running application. The rows and the columns of the main menu will be randomly flashed while the user stares the desired image and counts how many times the row or column containing it flashes. Thus, as it is more likely any other image flashes than the desired one, when the desired image flashes a P300 potential is elicited, approximately 300 ms after the stimulus. Analyzing the user’s EEG activity is possible to find out what row and column elicited a P300 potential. From this information it is possible to know what element of the matrix is the desired one: the intersection between the row and column that present a P300 response. Once the application knows the desired option it performs the command (pause, stop, resume) or accesses to the corresponding submenu (DVD, lights, telephone, multimedia hard drive, etc.). Every submenu shows the user a matrix of images related to different functions and options: switch on/off the device, turn up/down the volume, making a phone call, coming back to the main menu, etc. Likewise in the main menu, the rows and columns of the submenu are randomly flashed. Meanwhile, the user counts how many times the desired option flashes. Once the system identifies the desired action, it performs the corresponding command. For instance, if the user selects ‘switch off the TV’ the domotic application performs this command by means of an IR emitter device connected to the

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PC. Thus, users can navigate through the application menus and control the domotic and electronic devices.

Figure 1 shows the main menu of the domotic BCI application. The users can select the desired device or stop, pause or resume the running application. Figure 2 also shows the main menu. In this specific frame one row of the matrix, the first one, is flashed.

Figure 3 and 4 show the DVD and heating submenus, respectively. They consist on two 3 x 4 matrices of images depicting the basic options of these devices. In the frame shown in Figure 4, one of the columns of the matrix, the third one, is being highlighted.

Figure 1. Main Menu of the domotic BCI application. The user can choose between different devices usually present at home: TV, DVD, telephone, heater, lights, etc.

Figure 2. Main Menu of the domotic BCI application while running. In this frame the first row is highlighted.

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Figure 3. DVD Submenu of the domotic BCI application. The user can perform different commands over the DVD player: on/off, play, pause, forward, list, etc. It also allows the user coming back to the main menu.

Figure 4. Heating Submenu of the domotic BCI application while running. The user can select different commands of the heater: on/off, timer, increase/decrease power, activate/deactivate the swing option, etc. In this frame the third column is highlight

Discussion and Conclusion

The aim of this preliminary study was to implement a domotic application to increase the accessibility at home of people with severe disabilities. The usefulness of the implemented application will be tested and evaluated by users from the CRE of Disability and Dependence in the upcoming months.

A group of ten users from the CRE of Disability and Dependence has been formed to test the usefulness and performance of the domotic BCI application. Four users are the same that took part in our past studies [3, 4] with a motor imagery-based BCI application. Thus, we could compare the results achieved with both kinds of BCI systems. We found that motor imagery-based BCIs had an important limitation: users with severe cognitive disabilities could not control the system suitably. As P300-based BCIs are easier to use and they do not require an extensive training period [2], probably results using this new application could improve previous results. We also include six new subjects in the study to assess more suitably the performance of the domotic application. Comments and suggestions from these users will be taken into account to improve the application and make it as much as functional and usable as possible.

Our results will be compared with other studies [5, 6] working with disabled people. We hope to achieve similar accuracy results. Nevertheless, this study also proposes a domotic application to increase the accessibility at home, allowing the subjects to control usual devices: TV, DVD player, mini Hi-Fi system, lights, fan, heater, telephone and a multimedia hard drive.

Our application could also be expanded to control any domotic device placed at a digital or intelligent home. It would be possible to add new output interfaces to the application: Bluetooth, Ethernet, Wireless LAN, etc. Therefore, disabled people could access any device placed in their usual environment decreasing their dependence on caregivers, nurses, relatives, etc.

The present work is a preliminary study and it presents some limitations. Although the domotic application is already implemented, it has only been tested by healthy users from our laboratory. In the upcoming months we will carry out experiments with potential users of BCI systems, from the CRE of Disability and Dependence.

In summary, the present preliminary study proposes a BCI application based on P300 potentials to allow disabled people to control effectively the devices present at home. Potential users of these systems will test and evaluate the application performance. Accuracy will be compared with other domotic application using a motor imagery-based BCI. Our experience with healthy users suggests that the results could be higher using P300-based BCIs, as they do not require a long and extensive training period.

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DEVELOPING AN ACCESSIBLE VIDEO PLAYER

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Abstract: Online Channels in financial institutions allows customers with disabilities to access services in a convenient way for them.

However, one of the current challenges of this sector is to improve web accessibility and to incorporate technological resources to provide access to multimedia and video content, which has become a new form of internet communication.

The present work shows in detail the strategy followed when designing and developing the new video player used by Bankinter for these purposes.

Keywords: *Multimedia, Video player, Accessibility, Internet, Financial sector.*

Background

One of the challenges that directly affect online banking is web accessibility. In other words, that all people can accessing to all web content, independent of the limitations of the individual (disability) or of the context of use (technological or environmental) [1].

Several studies of disability in Spain [2] are emphasizing about the impact of age as a factor in the growth of the population with disabilities (in year 2008 there are 3.85 million disabled people, near at 1% of totally Spanish population).

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Table 1. Variables of impact in population disabilities

People between 6 year or more with disability		
	Rates per thousand people	
	Men	Women
Mobility	42,6	77,5
Domestic life	29,5	69,7
Self care	31,3	55,3
Hearing	21,9	28,4
Visión	17,8	28,4
Communication	16,3	18,6
Learning and development tasks	12,7	17,1
Social Interaction	14	15,4
Totals	72,6	106,3

These studies also show us, the fact that the mobility of persons is the major type of disability (see Table 1. Variables of impact in population disabilities), this last data is not only important for urban accessibility, but also for the importance to access bank services without having to travel.

For this reason, the possibilities offered by the "Online Banking" are evident [3] to improve services offered to customers with restricted mobility.

However, some studies focusing in to review the state of web accessibility criteria in Spain are showing the lowest percentage of successful at the online banking (see e.g. [4]) in the last years.

More exactly, 30% of the Spanish financial institutions do not fulfill the requirement WAI AA established by the legislation, and only 38% of these institutions reach accessible criteria to the transaction services.

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Accessibility in video content

Nowadays, there is a consolidated tendency to present video content on Internet.

There are several impacting data about audience video [6], we can see an example in February 2011, 170 million American internet users watched this type of content, and the average hours per month dedicated to watching them amounted to 13.6 hours.

Table 2. Use of video content in U.S.A

TOP U.S: Online Video Properties by Video Content Views
Ranked by Unique Video VIewers
February 2011
Total U.S.- Home/Work/University/Locations
Source: comScore Video Metrix

Property	Total Unique Viewers (000)	Viewing Sessions (000)	Minutes per Viewer
Google Sites	141,065	1.829,66	264,6
VEVO	48,998	222,11	81,2
Microsoft Sites	48,812	297,731	46,5
Yahoo! Sites	46,714	200,088	36,3
Facebook.com	46,661	170,319	18,5
Viacom Digital	45,214	229,856	74,2
AOL, Inc	38,773	137,362	23,1
Turner Digital	27,447	87,652	25,3
Hulu	27,257	143,461	224,3
NBC Universal	24,185	53,136	20,4
Total Internet: Total Audience	**169,646**	**5.038,49**	**816,4**

In case of web TV content, now there are initiatives like the recently approved in the U.S. (the Twenty-First Century Communications and Video Accessibility Act of 2010), in which both manufacturers and Web TV content servers should take commitment to the inclusion of measures of accessibility as the activation of closed captioning.

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However, for the specific case of web TV content, and the rest off video content, the accessibility requirements affect not only at the content, but also to the interface used in the reproduction.

On the other hand, for Bankinter as well as for others Banks, the video contents are powerful resources to make marketing action to clients, to give information about financial products and services, and to give advice services.

However, to include these contents it needs more effort because is more difficult to satisfy WAI guidelines, and this can become an obstacle in relation to expected improvements in accessibility for the financial sector.

Figure 1. Banner with product information of Bankinter.

In this line is important to mention, that the most breached guidelines by financial institutions [4], correspond to basic requirements of accessibility (WAI level A), and the inclusion of video contents affect both the first level and the second.

So it is easy to deduce why actions are not been taken to adapt this type of requirement to the financial web sites.

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Reviewing the accessibility of video players in the financial sector

As commented in previous sections, accessibility studies in different sectors attributed the financial sector as one of the worst in compliance with the existing web accessibility standards.

However these studies don't have specific information about the accessibility of video content for this sector in Spain.

In order to extend this information, and assess the impact for making accessible this type of content in Bankinter websites, we have reviewed the Spanish financial sector during year 2010 [5].

To do it, we selected a subset of 11 Spanish financial institutions that are currently presenting videos on their websites. And we analyzed compliance with specific guidelines (see Table 3) for accessibility applicable to video content.

In general, our results show that none of the analyzed financial institutions meet all the requirements suggesting by the WCAG for both levels (A and AA).

For the specific case of the Level A requirements, the majority of these institutions only comply 4 features in this level.

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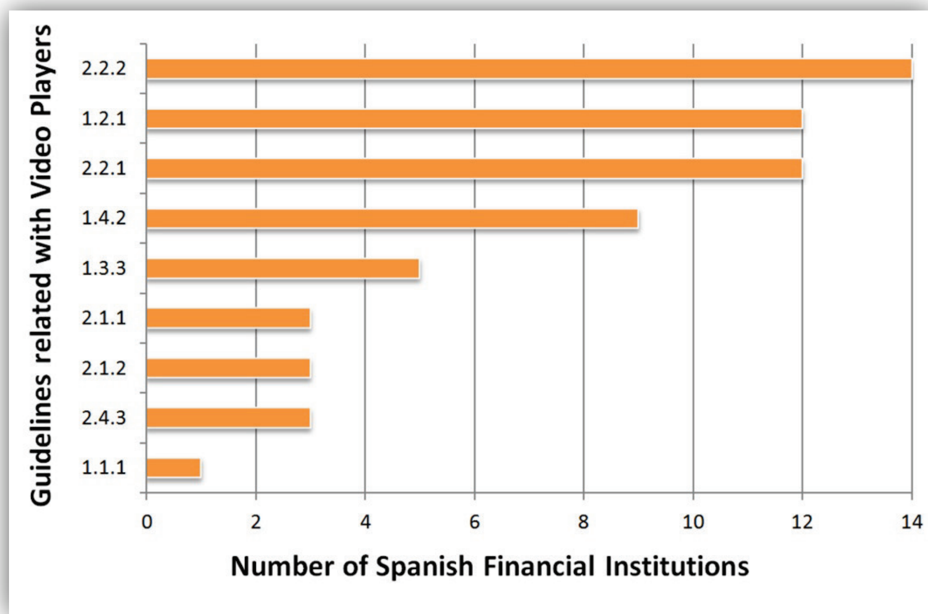
Table 3. Guidelines WAI levels "A" and "AA" applicable to video content.

Level	Guideline	Title
A	1.1.1	Provide altrenative text
A	1.2.1	Include pre-recorded audio or video content if the content is only video or only audio
A	1.3.1	Sensory characteristics of Interface components
A	1.4.2	Sound Control
A	2.1.1	Control by Keyboard
A	2.1.2	Retrieve the focus of the video player
A	2.2.1	Adjustable time limit video
A	2.2.2	Pausing and stopping the video
A	2.4.3	Logical paths in focus
AA	1.2.4	Subtitling
AA	1.2.5	Self-description
AA	1.4.3	Minimum contrast 5:4
AA	2.4.7	Focus with border visible

You can see the guidelines refer to existing features in most video players in the market, such as pause button, stop button and the scroll bar or sound control bar (with the exception of Guideline 1.2.1 which affect directly to the content).

Figure 2 Relationship of compliance with level A guidelines by Spanish financial institutions.

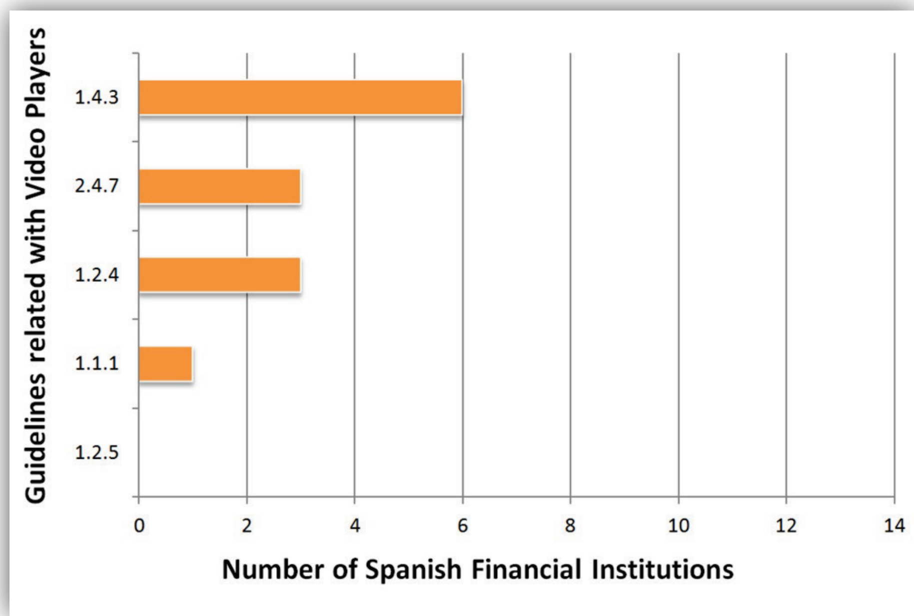


On the other hand, our results decrease significantly in the case of compliance with the guidelines of AA level, in this case none of the analyzed entities fails to reach half of the requirements placed on this level.

In relation to guidelines of level A, it is worth mentioning that 7 of 11 features of the video players used by these institutions are below of expected accessibility requirements.

In other words, most of the accessibility requirements not completed are related to the basic features expected of any video player.

Figure 3. Relationship of compliance with Level AA guidelines by Spanish financial institutions



Project Objectives

As we introduced in previous sections, the main objective of the project is having video content accessible in Bankinter Websites. This requirement is basic in Bankinter compromise with Corporate Social Responsibility.

The Internet architecture of Bankinter websites is based on streaming video servers, whose technology helps ensure the quality of the contents displayed

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on Internet, without affecting the performance of other services of the Bank.

The technology adopted by Bankinter incorporates several technical requirements, to include in any alternative proposed in this project.

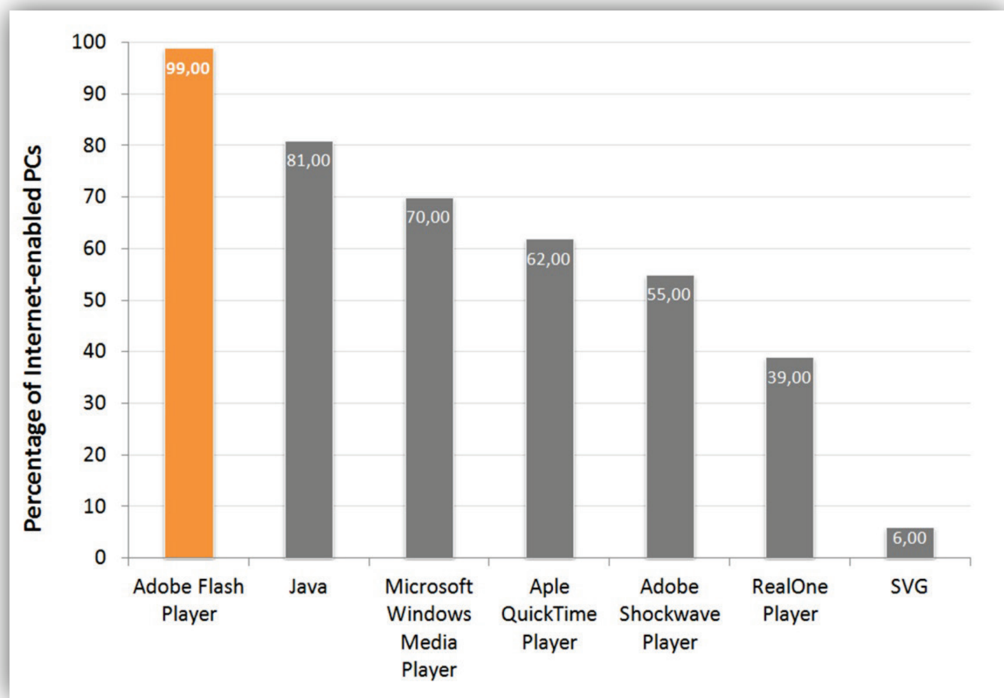
More specifically, functions related to broadcast video using RTSP (Real Time Streaming Protocol).

On the other hand, in 2010 the Bankinter web sites have begun migrating to new content management application; this project has set the highest priority in the Bank and regard to the accessibility of web content too.

Reviewing technological alternatives

Adobe Flash is a multimedia technology strongly used. It is used for everything, simple animations or complex interactive applications, and nowadays, Flash video (FLV) has become the leading video format on the web [6].

Figure 4 Distribution of different technologies of video players.



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As shown in Figure 4, today Adobe Flash technology is acquiring the highest percentage of use in the market.

For this reason, the main challenge in this study is to focus efforts on making this technology accessible.

Another decision made in this study is related with to the integration of video player in web sites. We can choice between: (1) make a video player only with JavaScript and DOM methods or (2) invoke an external video player with parameters <object>.

Both methods have their advantages and disadvantages, but after comparing these alternatives we was decided to develop a video player from components included in the framework of development of Adobe Flash.

And we focused in functions such as: (1) keyboard handling, (2), inclusion of captioning, (3) integration with adaptive technology, and (5) adaptation of readability and contrast conditions.

Features of Bankinter video player

The design of Bankinter video player was based on a set of international specifications for web accessibility, more exactly we considered the following standards:

a. Web Content Accessibility Guidelines 1.0
b. Web Content Accessibility Guidelines 2.0
c. Section 508 Standards

Based on these guidelines, we developed the first version of accessible video player (http://www.bankinter.es/), which has the following features:

Incorporating alternative text to the video player

In cases where the user does not have flash component to load the video player, we display a substitutive image accompanied by an alternative text explaining the existence of the video player to the users (see Figure 5).

Figure 5. Definition of alternative parameters to the video player.

```
<object type="application/x-shockwave-flash"
 data="/stf/comunes/consola_video/playeraccesible.swf?
 UrlVideo=/stf/plataformas/particulares/inicio/videollamada/videollamada_lengu
 a_signos/video/videollamada_lengua_de_signos.xml" width="340px"
 height="275px"><param value="window" name="wmode"><param value="high"
 name="quality"><param value="true" name="allowFullScreen"><param
 value="always" name="allowScriptAccess"><param name="movie"
 value="/stf/comunes/consola_video/playeraccesible.swf?
 UrlVideo=/stf/plataformas/particulares/inicio/videollamada/videollamada_lengu
 a_signos/video/videollamada_lengua_de_signos.xml">
<div class="img_generica_01_left">
<img
 src="/stf/plataformas/particulares/inicio/videollamada/videollamada_en_lengua
 _de_signos/sustitucion_video_1.gif" alt="Imagen del icono de lengua de
 signos. Nos ponemos en su piel." class="" title="Lengua de signos"></div>
</object><div style="margin:10px 0 7px;text-align: right;">
<a class="for_enlace_01"
 href="/www2/particulares/es/inicio/videollamada/en_lengua_de_signos/video"
 target="_blank" title="Resumen del v&iacute;deo. Abre ventana
 nueva.">Resumen del v&iacute;deo<img class="img_ventananueva_01"
 src="/www/cacheables/img/linkext.v1.cache.gif" alt="Abre ventana nueva"></a>
</div>
</div>
</div>
</div>
<div style="clear:both;"></div>
<div class="agr_vertical_contenido"><div class="caj_contenido_01">
<div class="dest_disc_02"><div class="caj_aviso_07">
<div class="corner_top">
<div class="corner_top">
<div class="corner_top">
```

Contextualizing the content of video

Next feature is related to improve understanding of the content.

To prevent data loss by failures due to accessibility or usability, a good practice is to incorporate a summary of the video content. (See Figure 6).

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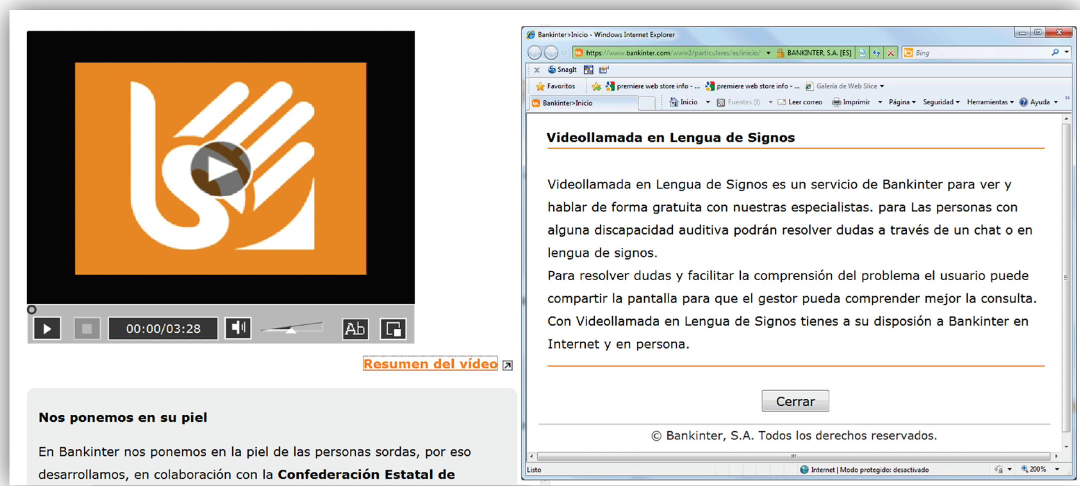
Figure 6. Summarizing media contents with the Bankinter video player.



Using Bankinter video player with keyboard

For people with disability main feature of the adapted technology is based on tracking the focus of interface components, these way users can interact with the applications.

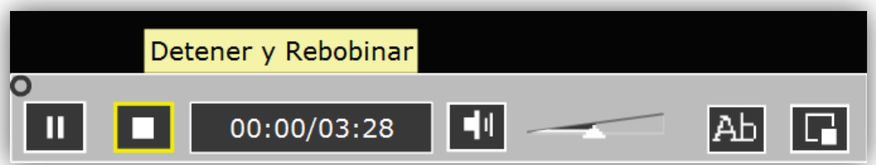
If the users can use a video player with keyboard, then they can track focus of the interface components. (See figure 7).

However, is not only necessary to track the focus also essential that users can predict which logical behavior of focus will be.

Therefore, focus of video player buttons must move as logical sequences no arbitrary jumps.

Finally, some buttons of video player can change of status (e.g., turn off or on the audio). To accomplish this feature, the ability to capture focus should be "inherited" for each of the buttons with change state property.

Figure 7. Tracking focus of Bankinter video player buttons.



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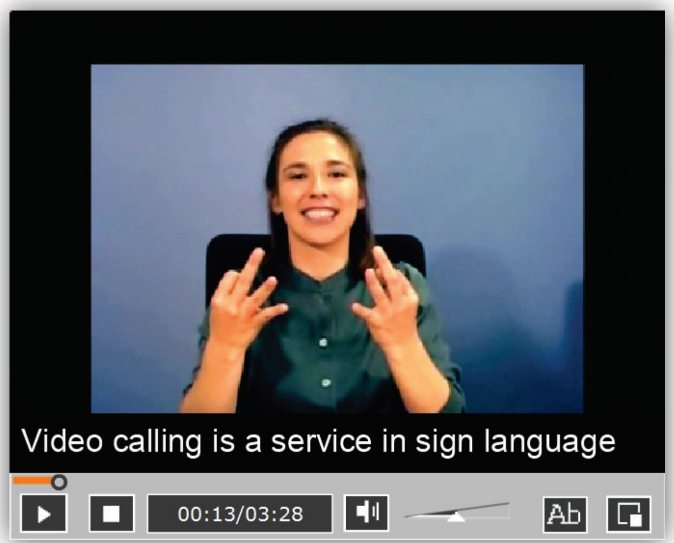
Inclusion of subtitles

It is obvious that video content must be accompanied by subtitles for hearing impaired users to be read by them (see Figure 8).

Figure 8. Presentation of subtitles in the video player Bankinter



But also, to create subtitles in the video content the video player should be based on existing standards of subtitling. It is the only way to avoid failures when we display video content through different Internet browsers (see Figure 9).

Figure 9. Definition of video content subtitles in Bankinter video player.

```
<?xml version="1.0" encoding="UTF-8"?>
        <tt xml:lang="en" xmlns="http://www.w3.org/2006/04/ttaf1"  xmlns:tts="http://www.w3.org/2006/04/ttaf1#styling">
                <head>
                        <styling>
                                <style id="emph" tts:fontStyle="italic" tts:fontWeight="bold"/>
                                <style id="quote" tts:fontStyle="italic"/>
                        </styling>
                </head>
                <body>
                        <div>
                                <p begin="00:00:10">Videollamada en Lengua de signos es un servicio de información financiera
                                <p begin="00:00:15">Resolvemos cualquier duda que pueda tener.</p>
                                <p begin="00:00:19">Nos comunicamos en lengua de signos o escribiendo por el chat.</p>
                                <p begin="00:00:47">Buenos días, soy Elena Madina</p>
                                <p begin="00:00:54">Buenos días, soy Cristina Fernández</p>
                                <p begin="00:01:03">Somos las responsables de Videollamada en Lengua de Signos</p>
```

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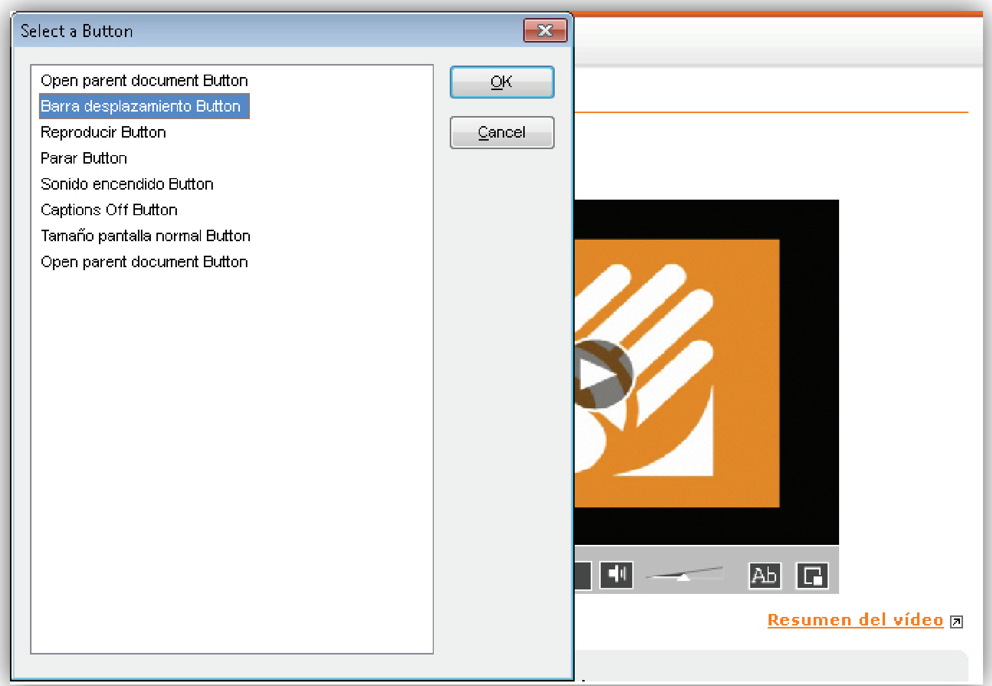
Turn on/off accessibility options

Many users with disabilities choose to access to the contents of web pages through adaptive technology, such as Zoom Text, Jaws, Windows Eyes, etc.

Ideally, the video players must be compatible with all adaptive technology, but several of these applications used by people with disability have not been developed based in common standards.

For this reason, an inherent property of video player must be to turn off accessibility features when there is adaptative technology together with video players.

Figure 10. Video player Bankinter running with screen readers (Jaws)



Maximize contrast and legibility

A very important feature that most market video players don't have is an appropriate visual contrast of their components.

A poor visual contrast affect to the population of users with low vision which have a useful visual rest.

The absence of adequate levels of contrast or legibility [7], result in the inability of low vision users to locate the functions of the video players, for example they cannot discriminate which is the symbol of "play" inside buttons of video players.

In our case the graphic design of the video player of Bankinter, has adapted its appearance to a number of color combinations to obtain levels of contrast, and color differences recommended by the WAI standards, as shown in Figure 11 and 12.

Figure 11. Visual contrast valuation on video player buttons and surrounding areas.

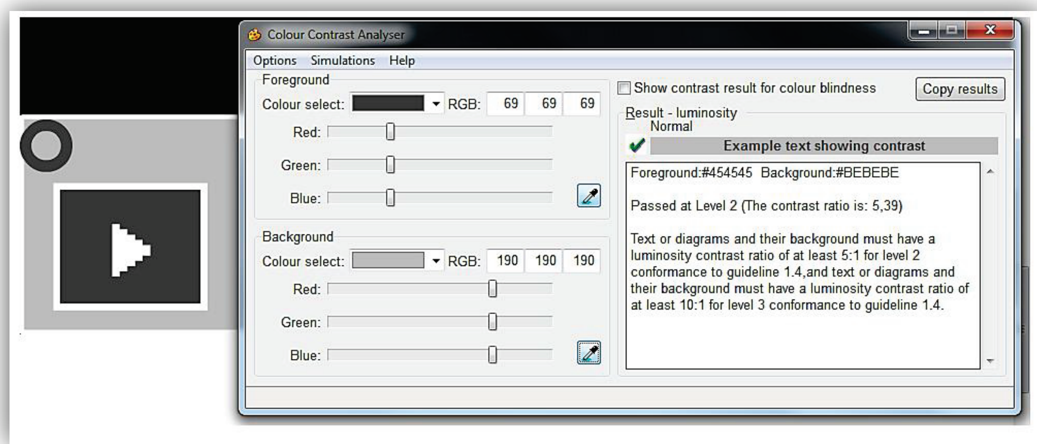
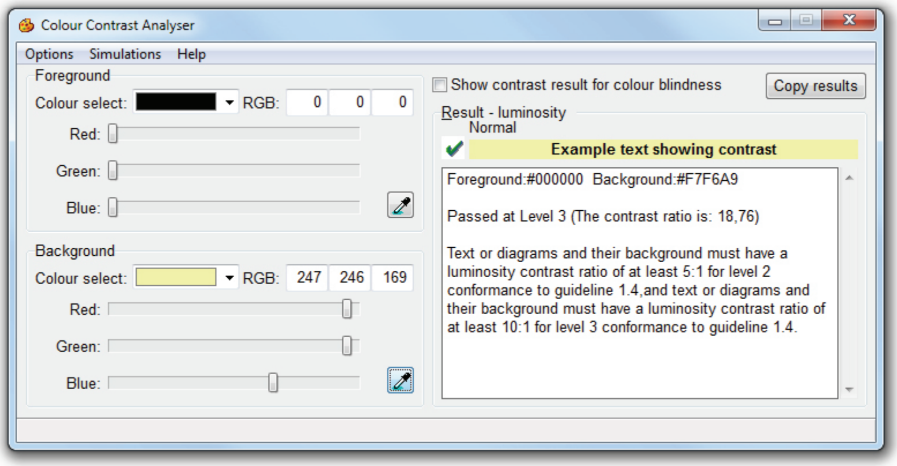


Figure 12. Visual contrast valuation on help text components of video player Bankinter.



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Conclusions and future work

The accessible video player of Bankinter has been published in January 2011. As a result of experience in the design and development thereof, we can draw some conclusions.

Firstly, the result of this experience is that benefits justify development investment.

As we have been showing throughout this work, the use of video content in Internet is not only a reality, but also involves a new way to communication way between customers and enterprises, included financial institutions.

The strongly demand of video online becomes a necessity to make video player accessible in the content and the way to present it.

The incorporation of the accessible video player of Bankinter offers new challenges related to the evolution itself.

We want to consider new video player functions such as accessible video galleries, RSS, TV channels, etc.

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PREDICTIVE SYSTEM TEXT ENTRY CONTROLLED BY ACCELEROMETER WITH ANY BODY PART

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Abstract: This paper presents an update of DasherUS, a predictive text system controlled by an accelerometer. The DasherUS software can be installed in any computer and it becomes faster with its use. Thanks to the calibration procedure included, user can put the sensor on any part of the body and, in a few steps, the system is able to adapt to the user mobility. In contrast to the previous version, the text can be now sent to any application that is running at the same moment of using DasherUS, without replacing any other application the user likes to utilize. Other improvements of the system will help us to polish DasherUS much better, carrying us closer to our objective: the guarantee that no one will be deprived of the right to express what feels any time anywhere.

Keywords: flexibility, text entry systems, access system based on accelerometer, dasher.

Introduction

DasherUs is presented by I. Gómez et. al (2010) as an augmentative and alternative communication system based in Dasher software. This research aimed to analyze possibilities that an accelerometer like a control device of Dasher software can offer to improve communication capabilities of people with disabilities.

It was proven that this low cost system reached text entry rates close to those obtained when the software is controlled with a standard mouse. Two lines were opened as planned activities:

1. To connect Dasher with input devices based on biosignals.
2. To study the use of accelerometers in telerehabilitation systems design.

In this work, improvements are established and a first version of DasherUS with some of these improvements is presented.

In section 2, state of the art is described. In section 3 system architecture is explained. In section 4 previous state of the system is exposed briefly. In section 5 improvements that can be done are studied. In section 6 improvements that have been done are very fully detailed. And finally, in section 7, conclusions are established.

State of the art

Several uses with dasher with different input devices can be found in (The dasher project). It can be used with a device based in breath in the 1-D mode (Shorrock, Mackay, & Ball, 2005). In the discrete mode, it can be used with buttons in different forms depending of the number of buttons (Mackay, Ball, & M. Donegan 2004). In the 2-D mode it can be used with eye tracking systems based on image processing (Ward&Mackay, 2002). Some proposals about the use of dasher with a Brain computer Interface system can be found in (Wills&Mackay, 2006; Felton, Lewis, Wills, Radwin, &Williams,2007) but results are not good, the conclusion is that at the moment another alternatives are preferable.

Accelerometers can be applied in Assistive Technology in different ways. In (Cech, Dlouhy, Cizek, Vicha &Rozma,2009; Hamel, Fontaine & Boissy, 2008) they are used in rehabilitation systems. In (Cech, Dlouhy, Cizek, Vicha &Rozma,2009) an automatic head position monitoring system is designed for controlling the recovery process after an ophthalmological operation. In (Hamel, Fontaine & Boissy, 2008) accelerometers and gyroscopes are settled in wrists and ankles to detect the appropriate movements in a telerehabilitation system design.

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In (Nakazawa N., Yamada K., Matsui T., Itoh I., 2005; Chen Y., 2001) accelerometers are placed on the head, they are used for computer access proposal. The systems described are complex because the whole computer control is pursued.

In (Sad&Poirier, 2009) the accelerometer is placed in a handheld device, effectiveness and reliability as an interaction device is evaluated. The advantage of using this kind of interaction is that one of the user's hands is free and the device's tiny screen is totally visible.

System Architecture

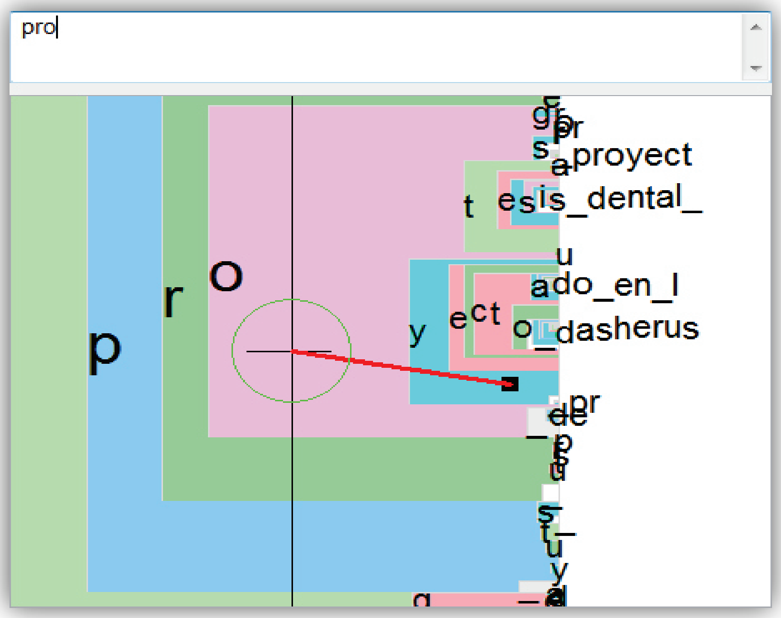
For the development of this research project, different technologies have been used. They can be classified:

1. Software, Dasher, that is the user graphical interface .
2. Hardware, including accelerometer and a microcontroller based system (*Arduino board)*. Accelerometer registers user movements while Arduino allows communication between accelometer and Dasher.

Dasher

Dasher is a predictive text entry system developed by the University of Cambridge. The user interface shows all the letters of the alphabet, which can be chosen by the user even including oriental symbols, inside of boxes with several sizes. Each of those boxes contains the entire alphabet too. By this way, the user has to move the cursor to one box and then move it again through one of the boxes inside of the first box. When the cursor enters in one box the software writes the letter it contains. In addition, this process becomes faster as the user writes with Dasher. This is possible because the software is able to predict what the user is going to write. The prediction makes some boxes bigger or smaller depending on the probability that the box's letter will be the next one. This interface can be viewed in figure 1.

Figure 1.User Interface of Dasher being used



Another of its advantages is the possibility to train the system with any text. Using statistical methods Dasher is able to infer what letters goes frequently after other. This inference process uses the training text and what the user is writing too. In the figure 1 can be observed how Dasher is modifying the size of the boxes according to this inference process.

Dasher gives the possibility to work with different operation modes: 1D, 2D, discrete input, etc. In 1D mode the cursor can be moved only across of one axis. Several screen ranges are defined to give the user the possibility to execute different actions when the cursor enters on that range. In 2D mode the cursor is moved like a standard mouse in any direction. Finally, with the discrete input the software can be used only with one event: a button, left-click, right-click, etc.

In our case, we use the 2D mode to control Dasher using an accelerometer. Thanks this, any user can utilize Dasher with movements of his/her body moving the cursor as if you were using a traditional mouse.

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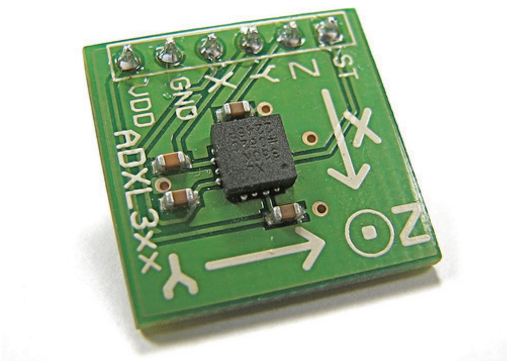
ADXL3XX Accelerometer

This hardware component is in charge of measuring the accelerations produced by the movements that we apply to the system. There are a lot of accelerometer types based on different technologies like electromechanical, optical, thermal, capacitive, magnetic induction, among many others.

The way an accelerometer works is so simple: a damped small mass with a spring and when the accelerometer experiences acceleration, the mass is displaced. The displacement is then measured to give the acceleration.

Figure 2. Picture of an accelerometer ADXL3xx



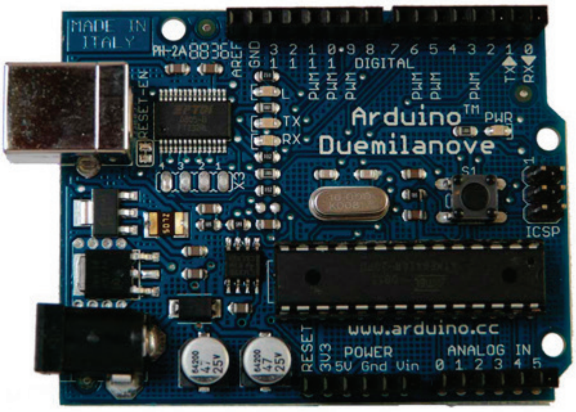
Our accelerometer is the model ADXL330 (Figure 2) from Analog Devices and uses the technology called MEMS (MicroElectroMechanical Systems). The sensor is a polysilicon built in a silicon board. Silicon springs suspend the structure and provide resistance against acceleration forces. The structure displacements are measured using a variable capacitor that is able to change its output depending on the movement. This process is possible because the capacitor has inside parallel plates which distance between them is different when the structure is displaced. The distance between plates its proportional to the accelerometer's output.

This small device can be placed in any part of the body. Thanks this, we are able to obtain any movement the user. Processing those data, the user can utilize the accelerometer to control Dasher instead of the mouse. However it is needed another element for this system. That element will receive all the information from the accelerometer, will process it and will send to the computer. This element is called Arduino (figure 3).

Arduino

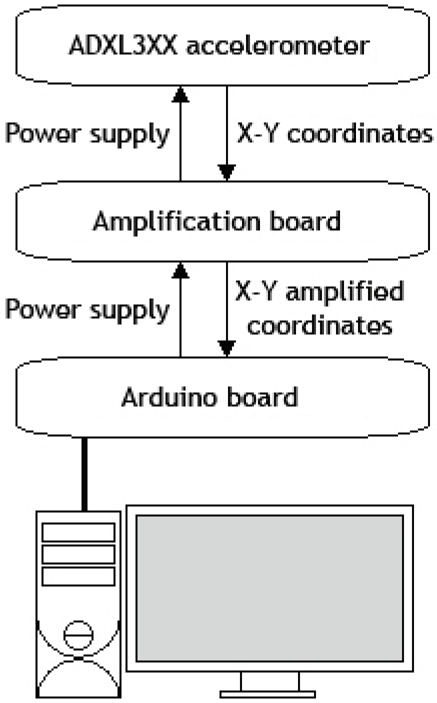
In 2005, Smart Projects company decides to launch a free programmable hardware platform using a simple development environment based on C programming language. Its easy programming and the number of the existing devices to extend hardware such as touch screens, GPS, Ethernet or Bluetooth among many others, make this board a cheap and affordable alternative to work on research projects. This board will act as an intermediary between the PC and the accelerometer (Figure 4).

Figure 3. Picture of an Arduino Board



The model that we use is the Arduino Duemilanove. This board incorporates everything needed to program it so that the user can execute their designs in it. His microcontroller is a Atmega328 at 16MHz and has 14 digital input/output pins and 6 analogical inputs. A USB Type B connector by means of which connects to the computer is included, communicating via a FTDI chip that converts USB signals for transmission through a virtual serial port.

Figure 4. System Architecture Connection Diagram



The accelerometer detects toward where we are moving and sends those data to Arduino. It collects the data, interprets them, applies a moving average filter and sends the result of that processing to PC in a format understandable for Dasher. These data are used to control the cursor.

Previous State of DasherUS

To take stock of the state of DasherUS must differentiate on one hand the state of Dasher version that we used to implement the system and on the other hand the changes that we made on the source code of that version.

We began to implement DasherUS on 4.10.1a version of Dasher. This version had the following characteristics:

- Language: Selection of the alphabet to use. Orientation writing and prediction options.
- Control: Selection of style control and input device. Speed options. Start and stop writing options.

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- Appearance: Selection of color scheme. Cursor and boxes appearance options. Font options.
- Aplication: Toolbars, dictionary, Voice and clipboard options.

In its previous version, DasherUS presented the first implementation of the system. It was a very basic version that we use as proof of concept and was intended as the basic schema for future revisions. In this version the following features were implemented:

- Control: Use the accelerometer as an input device.
- Calibration: Ability to calibrate the accelerometer.

Features to be improved

As it is mentioned in before section, DasherUS is a versatile software. However, it has not an important characteristic: Does not allow to send text to others applications. An augmentative and alternative communication system must not be only a direct communication system between people who are in the same place, but also must allow to communicate in a remote manner with other people. In addition, a handicapped person could want to write in a blog, a book, to make a relationship by Internet, an electronic mail, etc.

There are some features to improve in the implementation of DasherUS. The previous version was a prototype.

In other hand, a study of how DasherUS is used could gather interesting information. Some parameters such as fatigue, usability, text entry rate, etc. could be meant by recording each user session. The recorded information could be used to make the system easier to use. Also, new systems could be designed to meet their needs.

In this system, a mouse device is implemented using an accelerometer. This device replaces a conventional mouse device. If a conventional mouse device is required, it is necessary to offer to the user an alternative to select which device he/she is willing to use.

To control DasherUS using an accelerometer it is required to install Arduino on the COM3 port of the PC. However, technical knowledge must not be required. Therefore, an automatic port detection or setting options must be implemented.

The first version of DasherUS is controlled successfully using an accelerometer, but the way in which this interaction is shown on the screen could be improved. The used accelerometer means using a small range of 300 values, and therefore the DasherUS cursor is moved in a discontinuous manner because of a higher screen resolution (640 x 480). To solve this problem, a circuit which amplifies the accelerometer measures up to 1024 values could be designed.

Present state of DasherUS

After detecting the features which could be improved, we started to work to make DasherUS a more efficient and useful system. Two priority points were focussed on:

Send text to others applications

DasherUS has to be a system that helps people. A system with many restrictions does not work. During the development of DasherUS, we visited to some disables organizations whom members have active blogs in Internet and use instantaneous message applications. The difficulty to entry text using their systems is a hard challenge for them. Sometimes a too large physical effort is required (Figure 5).

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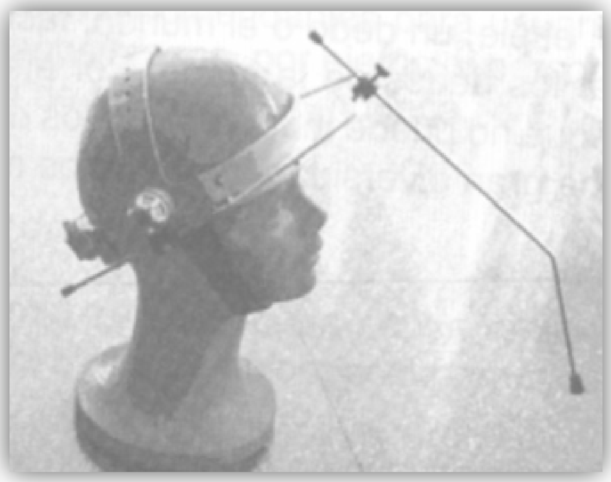
Figure 5. Unicorn Picture

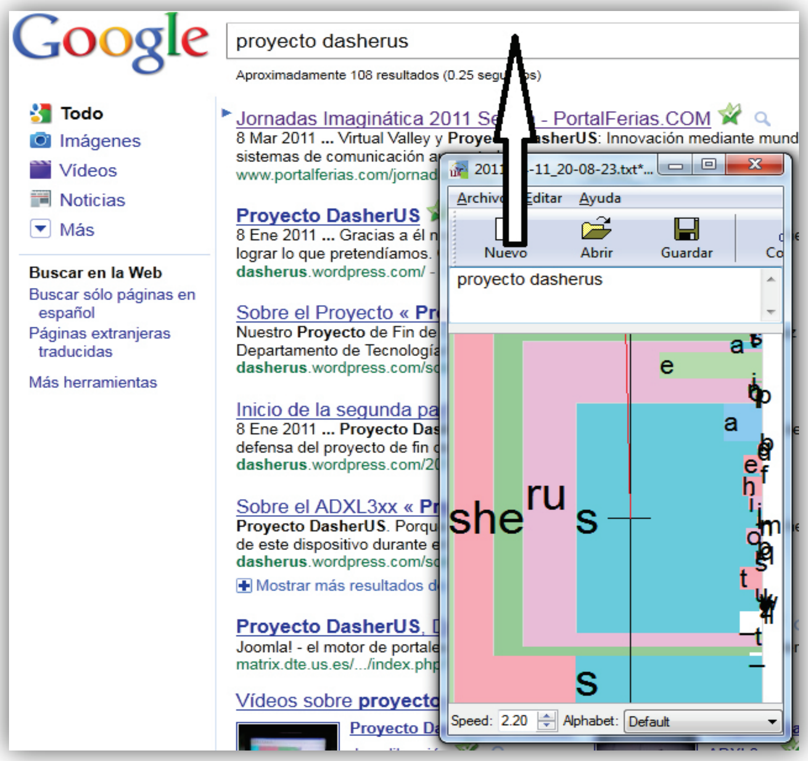


DasherUS cannot replace an Internet Browser or an instantaneous message software. However, it can be a support to use these applications. As in others accessibility tools, DasherUS was improved to communicate with others applications.

A procedure to send the text to the last focussed window before DasherUS was built (Figure 6). The text is sent when the user stops the entry. This stop is detected when the cursor is located inside of the small central circle during some seconds, and then, a stop command is sent. If the “send to others applications” option was selected in the settings, the text is sent immediately without an user interaction.

Users are less reluctant to use DasherUS because of the improvement. In this sense, DasherUS is a support and not a substitute of applications that they usually utilize.

Figure 6. Sending text form DasherUS to Internet browser



Logfile

DasherUS is part of a research project so it is not just an end product but a mean to get information too. The logfile includes time marks, the user selected text, the cursor position on computer screen, data sent by the accelerometer, etc. The logfile allow us to get statistical information from an user, or group of them, such as average character selection time, number of errors, etc. Moreover, it also let us replay the whole experimental session, so we can identify user's movement patterns and recognize the involuntary ones (such as spastic movements, twitches, etc) that can make users difficult to use DasherUS. Identifying movement patterns will improve the user-computer interaction, for instance, by filtering involuntary movements out, what, in turn, will increase the text input rate and reduce user fatigue. To sum up, the logfile allow us to improve DasherUS and increase the number of its potential users.

Conclusions

We had already obtained good results when we used the first release of DasherUS in 2010 getting a high text entry speed. Even though the system was still unstable when it was first used, and seemed to be quite difficult to be used by people with disabilities, it got an unexpected and favorable reception among the people who used it. In comparison with previous applications, DasherUS let people increase text production quickly and easily. Our personal interaction with them gave us enough experience on how to improve DasherUS. Currently we have turned the application into a real augmentative and alternative communication system by which these people can communicate with people closer to them, who can read the screen or hear the synthesized voice generated from the text, or people around the world by sending the output text to a any current internet application like an email, application, facebook, etc.

The fact that there was a person who has been able to get his feeling across on a blog using DasherUS moved and encouraged us to go on including new capabilities to this software so that it can be used to a wide range of disabled people.

Acknowledgments

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A SENSITIVE TECHNOLOGY FOR A SENSITIVE CHALLENGE

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Abstract: This paper deals with technology and its applications for an ageing population. It aims at discussing the issues raised by such a relationship and highlights healthcare-related designs. It questions the notion of product acceptance and points out some challenges that need to be met by designers and engineers. The overall experience provided by owning and using a product must be designed in a holistic way, placing the human, his or her needs and feelings, as central guiding factors. These issues are further explained with the presentation of a design project made by Audrey Dodo and Teresa Georgallis, within the frame of a competition at the Royal College of Art in London: a self-monitoring health service, a toothbrush that assesses the user's health state through his or her mobile phone.

Keywords: design for all, universal design, ageing, technology, utility, usability, acceptability, empowerment, health care, emotional acceptability, sensitive design, Blackberry Aid

Introduction

"New technologies" are invading our ordinary lives. They *augment* our daily lives by their ever-increasing presence and can potentially find a place anywhere, certainly even where our imagination would less expect them. The most incredible scenarios can come to life: science fiction inspires the evolution of technologies and we are now used to what we could not even have imagined just a few years ago. Today's fiction is tomorrow's reality. We can see how fast technology is going and how it thus disrupts product life cycles. New forms are born and hasten the obsolescence of former forms.

The ageing population has opened technology to other areas of research and oriented discussions towards the performance of our environment to respond to the functional and cognitive heterogeneity inherent in human beings. Diversity is the challenge. What are the issues it raises? How can technology and ageing coexist? How can technology respond to ageing?

Design issues in the context of an ageing population

Utility and usability

We experience the direct power that technology affords [1] to people; speaking about "superpowers" is not a euphemism. If a "simple" product is able to offer its users new ways of action on their environment, a product based on state-of-the-art technology is much more powerful, as it significantly increases a human being’s natural capacities. "I can't be everywhere at once" is no longer receivable on its own. Ubiquity, teleportation are common gifts given by our everyday devices. What is important is not to wonder what technology can enable us to do, but rather, how we need to design technology so that it will benefit people.

The main concern behind the "what" question is the utility of the product. However obvious this may be, this criterion can be so easily avoided by seeking spectacular technological effects. Indeed, "new technologies" liberate designers from their creative thoughts (or any other people involved in the making of our environment), notably contributing to an upward spiral. Users' real expectations need to be kept in mind so as to abort unnecessary functionalities, which could potentially complicate the system. However, even useful, the best innovative product of all may turn out to be the one that we will never want to use.

When everything becomes technologically feasible, a product differs from the others by its usability (ease use), that is to say, its ability to respond to people's diverse cognitive and physical capabilities. From the norm ISO 9241-11, we can deduce that the quality of usability corresponds to the diversity of people who can use a product to achieve specified goals with

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effectiveness (task completion), efficiency (task completion with minimal time and effort) and satisfaction (user experience). Thus, if a product, because it is useful, empowers people, it means that it can be easily used. Usability needs to be placed at the centre of the making process. At a time when the worldwide population is ageing, there is no doubt that this criterion can no longer be ignored, and must be involved in the making of socially and economically reliable products.

Functional segregation and "situation of handicap"

The older population is precisely pushing forward the debate concerning the "functional segregation" [2] operated by our environment – a debate that was brought out by people with disabilities, leading Ronald Mace (an American architect and designer who contracted poliomyelitis at the age of nine) to coin the concept of Universal design [3] (also called Design for all or Inclusive design in Europe) in 1977. If our environment can empower people, it can also disable them: "(…) urbanisation is characterised by a design apartheid in which the design of the built environment actively disables disabled people (…)" [4]. This quote highlights the understanding of disablement as a process engaging the environment.

Indeed, environmental factors impact on the accomplishment of life habits (daily activity or social role). We can easily figure out the limits of the medical model of disability that corresponds to a linear conceptualisation based on a cause and effect relationship between impairment, disability and handicap (International Classification of Impairments, Disabilities, and Handicaps or I.C.I.D.H. by WHO, 1980). Here only the individual is held accountable for the difficulties he encounters (personal factors). This model does not call into question the ideologies that govern our societies (the worship of performance and the notion of norm) and leads people with disabilities to comply with the required standard (rehabilitation). However, there is no handicap per se. The negative or positive power of our environment can be understood thanks to the systemic model that considers the person within his/her environment and defines the handicap as a situation of failure in the accomplishment of a life habit, resulting from the

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interaction between the individual and his /her environment (In France, Pierre Minaire and Claude Hamonet, were pioneers; their work led Patrick Fougeyrollas, in Quebec, to develop the Processus de production du handicap - P.P.H., 1998 [5]). This systemic conceptualisation rightly expresses and specifies the major role of the quality of use of our environment. The discussion generated by the P.P.H. led W.H.O. to revise the International Classification of Impairment, Disabilities and Handicaps (C.I.D.I.H.), with the adoption in 2001 of The International Classification of Functioning, Disability and Health (I.C.F.), which, for the first time, included a list of environmental factors.

Not only does our environment disable people with disabilities, it can also disable anybody. Indeed, the systemic conceptual model makes it possible to understand the universality of disability and its relativity: if handicap is a situation, it is not constant. Thus, everybody can face a situational handicap (Pierre Minaire, concept of "situational handicap" [6]), especially people who are more demanding with regard to their environment as pregnant women or people carrying heavy loads. Whether they are obstacles or facilitators, environmental factors can cause or prevent situations of handicap. Thus, our environment has a real impact - positive or negative - on personal factors. For example, by hindering the progress of an action, a product can negatively impact on the psychological health of the person (stigmatization, limited participation) and on his or her physical health (chronic disease, accident...). As the current social fabric evolves, there will be increased demands for a better usability. This evolution needs to be considered carefully so as to meet the challenges of ageing.

The concept of Universal design defined through seven general principles (equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, size and space for approach and use) that were established by R. Mace along with experts in 1993, sets guidelines in order to achieve, as far as possible, a universal usability. We can see Universal design as the process of transferring the expectations of performance from the individual towards the environment, which is then expected to suit people's needs. Indeed, R. Mace was quick to

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understand the significant role the environment plays in the disablement process, and conceptualized it into a creative approach, hence the universality of disability. He thus extended the concept of accessibility that was originally limited to the built environment and used to exclusively refer to "disabled people".

People involved in the making of our environment (designers, architects, engineers, decision-makers...) need to take into account the diverse range of capabilities that characterizes human nature in order to prevent possible situations of handicap by providing a good usability. Basically, it means paying attention to ergonomics through a holistic approach that considers all the interactions involved in using a product within a specific environment, in a variety of contexts.

Acceptability

If the question of utility is becoming critical with technological progress (useless functions), so is usability. Sophistication leads to complexification, the flow of innovations leaves no time to adapt, and electronic processes, which are not as easy to understand as mechanical processes, need translating into meaningful designs. Products that incorporate new technologies without adequately providing usability can leave their users far behind, especially people with disabilities or older people. Ease of use is crucial and the ability of a person to make use of a product depends on it. This is truly a basic design requirement and yet it is often overlooked.

However, if we keep the systemic model of disability in mind, we can see that utility and usability alone do not suffice to define what makes a product easy to use or what makes the user want to use it. The acceptability of a product is amiss when it confronts a person with a situation of handicap that is harmful to his/her psychological health (self-confidence) and physical health because his/her life habits cannot have been properly accomplished. But beyond this practical side, even if a person does not have any trouble using it, the product can send a stigmatizing image so that its user may not want to use it. As Jakob Nielsen said, "usability is a narrow concern compared to the larger issue of system acceptability" which is the

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combination of the "practical acceptability" (utility, usability, cost...) and the "social acceptability" (norms and values) [7]. Designing non-stigmatizing products is a concern that relates to social acceptability. It is in the vein of the Universal design approach that transforms, as much as possible, specific needs for specialized products into mainstream needs, leading to the making of mass market products that are not labelled "disabled", "weak", "unable".

The importance of social acceptability has been enhanced by technological progress, which is profoundly changing the way we design our environment and the way we interact with it. Life today is utterly different from life in those days that preceded major innovations (fast means of transport, mobile phones, computers...) and every day our relationship with the world is changing. We need to face and adapt to these changes that empower us much more than what nature ever intended. This shows that social acceptability cannot be overlooked. As Donald Arthur Norman said, “we must design our technologies for the way people actually behave, not the way we would like them to behave” [8]. Design has a real role to play so that these changes may positively affect people's lives, and stressing, beyond their practical acceptability, their social acceptability.

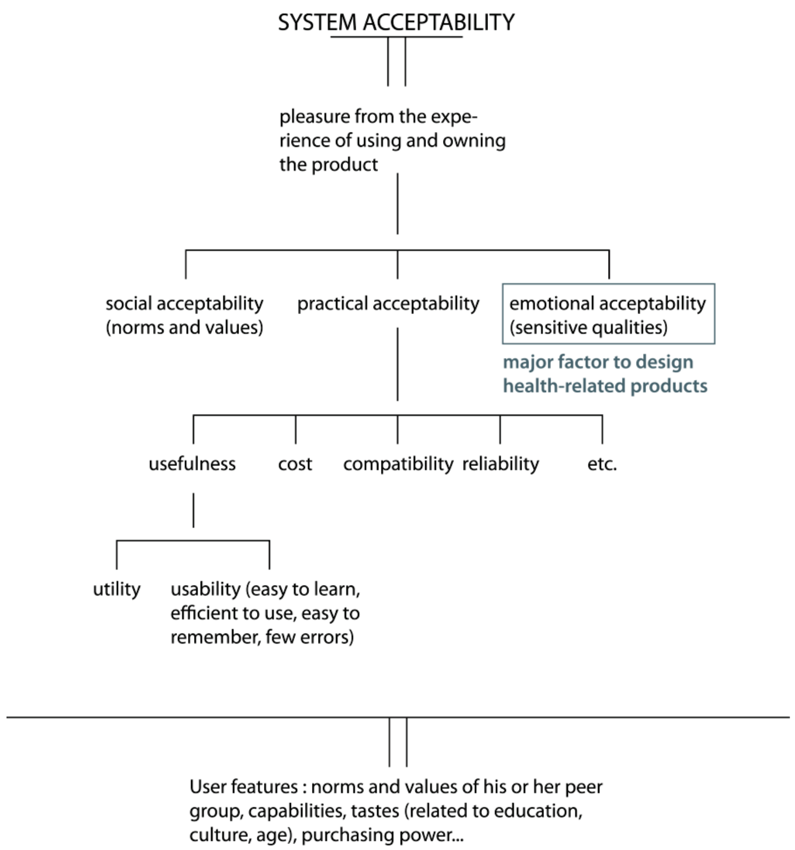
Health care related technology

The importance of emotional acceptability

We can consider that the acceptance of a system by a person is eventually determined by the interaction between the actual acceptability (product features) and personal factors (user features: norm and values of his or her peer group, capabilities, tastes - related to education, culture, age - purchasing power…). The quality (pleasure) of this interaction conditions the user’s acceptance of a product. That is the perceived acceptability, which results from the experience of owning and using this product, and raises the question: is the experience enjoyable?

The impact of such an experience on a person’s psychological state is, in J. Nielsen’s conceptual acceptability model, the "subjectively pleasing" aspect that is one dimension of usability. We argue that the pleasurable dimension should not be part of usability. Indeed, a product can be easy-to-use and socially acceptable while the overall experience that it provides is unpleasant and questions what we will call its emotional acceptability (sensitive qualities of the product). From our point of view, the overall acceptability of a system depends on the pleasurable aspect of the experience it provides, which in its turn depends on practical, social and emotional acceptability. Especially in health care designs, this third dimension that we call emotional acceptability is decisive for a product acceptance and can prevail over practical features.

Figure 1. Acceptability model.



Some "superpowers" can destabilize, especially when the technology that confers them is closely related to your body because of (1) its location - embedded technology - (2) its way of functioning –somehow dependent on the human body - (3) its formal or functional aspects - bionic technology -

for example. The concept of acceptability cannot be restricted to these two social and practical dimensions. A product may well have positive representations and be given an undeniably useful purpose (health) but also be disturbing for the individual who has just gained an incredible power. It may be scary, for instance, to be able to prevent diseases or to control them. The potential of a product has to appeal to people's humanity. The distance created between the "natural" state and the "empowered" state must be open for acceptance by people so that they can assume new capabilities that exceed their human condition. Acceptance also relies on - and thus must be inclusive of - the qualities of the experience provided by owning and using a product. What does it feel like to use this device that enables you to be informed of your state of health? How is this information provided? Will such a product appeal to you?

Case study - A self-monitoring health service: issues at stake

In the context of an ageing population, technology is expected to mean better living for all. Good health relies on good quality of life, which depends on personal factors, and above all, on the environment (systemic model of disability). If products that incorporate "new technologies" can have a positive effect on people's lives, thanks to their utility and usability (as other products can do), they can more particularly have the power to directly sustain people's health. Health is an intimate and serious issue that embodies a real challenge for interaction design. The user-product relationship must be carefully designed. When a relative speaks to you about your health, he or she will naturally sound both concerned and considerate; he/she will behave in a pleasant way. Your doctor might sound less sentimental but will nonetheless take care of your wellbeing. What about a device that beeps frighteningly to remind you that you should take your pills? The design of a product (its aspect and its interactions with the user) must fit people's psychological schemes. Concerning health-related products, the way that the information is given does impact on the mental state of a person, who, in a poor health condition, can prove to be more fragile.

This is the challenge that we undertook as part of an interdisciplinary competition called “Blackberry for body and life” [9] led by the Helen Hamlyn Centre of the Royal College of Art in London, which is specialized in Inclusive design, in partnership with Research In Motion, the designer and maker of Blackberry.

The brief proposed to RCA students gave them enough freedom to conceive prospective technology-based scenarios in an inclusive design approach. At that time, I was an intern researcher at the HHC and I took part in this one-month long project. With my team, made up of designers, one of whom is Teresa Georgallis, we decided to design a service that could help people to be aware of their general health state.

Throughout their lives people undergo changes and are capable of adjusting to their environment (up to a point). The ageing of the population and our fast- paced existence (stress, tiredness) leave no time to correctly look after our health and contribute to increasing diseases that could be prevented if we could find a way to easily inform ourselves. Indeed, the future scenario that we propose enables you to check your vital signs, thanks to a customized application. The idea is to encourage new health-related behaviours: being attentive to your body, communicating with yourself before (better) communicating with others, and adjusting your behaviour in accordance with your physiological signs. It is about supporting prevention by enabling people to evaluate their own health and decide if they should consult a doctor. Numbers of people do not even know that they actually have a disease, some do not have time to take care of their health, and others know that their family is liable to certain diseases, while more vulnerable populations, like older people, need to check their health state regularly.

Illness is a constitutive part of the human condition, everybody is concerned and needs to be sensitised on the issue. Thus, we wanted to design a service "for all" that would suit to a large range of people’s needs in terms of prevention (patients who require a regular follow-up care and people in general) and that would make them more attentive to their health.

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"Digital technology has changed the way we interact with everything from the games we play to the tools we use at work. Designers of digital technology products no longer regard their job as designing a physical object - beautiful or utilitarian - but as designing our interactions with it." [10]. Digital technology is a chance to enhance possibilities of interactions between the user and the product, and think of a closer and sensitive relationship.

Further to the service that we propose, our concern was the way the information is accessed and designed, and how it is integrated into a person's life. What could be the sensor and the product that indicates the state of health? What information should be provided? How should it be designed? How, when and where can the user access it? We needed to design an overall scenario that could incorporate all the qualities required to make this service human-friendly.

The sensor relates to the phase of monitoring and recording of the vital parameters, while the device-interface (whether it includes the sensor or not) relates to the phase of synthesis of the recorded data. Both phases need to be attentively designed. The first one must not be intrusive and the second one must not be scary. Keeping this in mind, we thought that objects already incorporated into our lives for other uses would be really appropriate, as they are not mentally related to a medical process. Thus, it would facilitate the formation of new behaviours regarding health. The objects that fitted these criteria and that we thought appropriate to these two phases are the toothbrush for the monitoring phase, and the mobile phone, for the phase of synthesis. Both are objects that most people commonly use everyday.

The toothbrush relates to hygiene and care. As a sensor, this intimate and personal object allows collecting information through saliva, the pressure of the hand on the handle, or bleeding gums. As we first brush our teeth in the morning, we are consequently able to analyse our blood sugar levels, as well as our blood pressure, on an empty stomach. Moreover, having the toothbrush as a sensor enables a comparative analysis of the monitored physiological signs at key moments of the day.

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The mobile phone is a device that is usually carried all the time by its user (as a garment is) and that is personal to him or her, which implies two advantages: it brings confidence to the user and the information remains fully accessible and potentially confidential.

Case study - A self-monitoring heath service: design choices

Let us imagine that while you are performing the simple act of brushing, the toothbrush picks up your vital signs, quietly monitors your wellbeing and sends the data to your mobile phone. This aid does not require any extra thought, and self-monitoring is naturally embedded into your daily life. Should you want to find out your general health state, you can access the data easily on your mobile phone.

Beyond this general scenario, the design of the toothbrush and of the interface follows the same human-friendly concerns. The toothbrush is stylish; its appearance does not give any idea about its actual extra medical function. It even becomes attractive and appealing, as cosmetic products are.

Figure 2. Prototype of the toothbrush (sensor)

The data provided by the toothbrush is translated into friendly animated figures: the interface communicates the information in a visual way that is pleasing and not intimidating for the user [11]. As previously mentioned, our main concern was to favour a sensitive interaction in the course of its use. The way the information is given mustn't be scary for the person, as medical design can be.

The vital signs that are monitored are listed in three categories that can be accessed from the home page: "Eat", "Breathe" and "Beat". "Eat"

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corresponds to the blood sugar levels and the body water, “Breathe” indicates the blood oxygen levels, while in “Beat”, you find pulse rate, blood pressure and temperature. These parameters altogether feature the main alert signs. The categories are represented by three concentric circles split into three equal parts that are singled out with colours, respectively green, blue and red.

Figure 3. Home page, normal health state

When you open the application, each part moves and gets distorted separately until they stop simultaneously and give a summary of your general health state. The static diameter of the pie chart (reference circle located in between the other two) represents the state of equilibrium, in accordance with your personal vital signs. The outer circle expresses the average of the highest values whereas the inner one represents the average of the lowest values. For example, if all the values corresponding to the vital parameters from the “Beat” category are higher than the expected balance, only the outline of the specific portion of the external circle will move outward. On the contrary, if some values are lower than the expected balance, the outline of the inner circle will move towards the centre. The average of the highest values is distinguished from the average of the lowest values by a darker colour; the reference colours are those of the circle that represents the balance. You can get further details concerning each parameter by accessing the category of interest.

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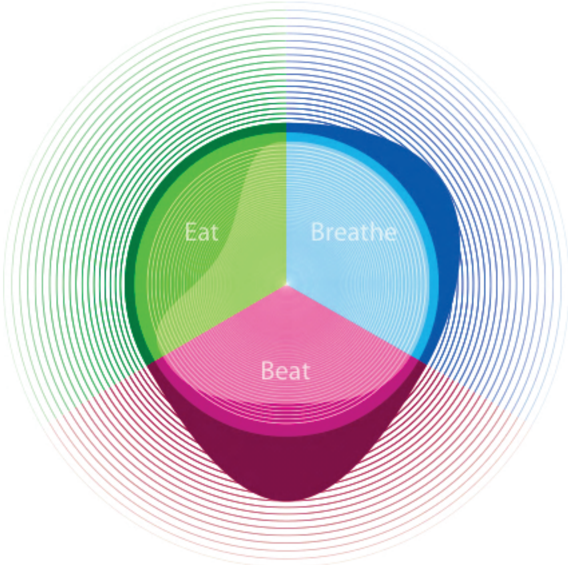
Figure 4. Home page, unbalanced health state.



Each vital sign is presented through animation expressing the values. No figures are given. Indeed, the given data allows the user to evaluate his/her health state but cannot be seen as a substitute for a medical consultation. That is an important point: this application just cannot replace a doctor's diagnostic. If the person desires it, the data can be directly transferred to his/her doctor, who can do an in-depth diagnostic. Even if we may envisage another version of this application that could feature numerical data with the doctor's consent, an interface that indicates the actual health state exclusively through figures would be emotionally stressful.

However, we wanted the design of the animations not to be reduced to an abstract codification of the vital signs, but keep the design sensitive. Indeed, we were inspired by real microscopic views and molecular representations that refer back to the parameters, in order to favour a more intimate communication with our body, opening on to a better understanding. These design choices support a humanization of technology. A person can figure out how his/her body functions as accurately as possible, without compromising the sensitivity of the interface.

In the "Eat" category, the sugar level is indicated by a circle (blood vessel) in which two other circles materialize different glucose levels. The reference point (normal level) corresponds to the intermediate circle. Glucose molecules are represented with an accumulation of white rounds discs

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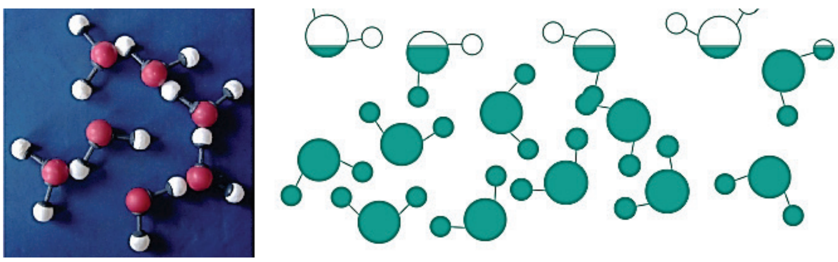
expressing its chemical structure. When they move to reach the outline of the artery (biggest circle), the sugar level is high; it is normal when they move until the intermediate circle, while it is too low when they remain within the little circle.

Figure 5. Sugar level, "Eat" category

The body water is represented by the water molecules (designed according to their chemical representation, with two Hydrogen atoms linked to one Oxygen atom) that move on the screen and lose their blue colour (they "empty" their water) when they reach the virtual line symbolizing the current level. The upper part of the interface corresponds to the quantity of water needed by the person. The lower the dividing line on the screen, the more dehydrated the person.

Figure 6. Body water level, "Eat" category.



In the "Breathe" category, the blood oxygen is represented by a ring made of little discs releasing blue bubbles; this symbolizes a lung alveolus providing our organs with oxygen. The direction of the oxygen coming out of the alveolus indicates the level. For example, when the level is low, the blue discs concentrate in the lower part of the screen (lower part = low level; upper part = high level; centre part= normal level).

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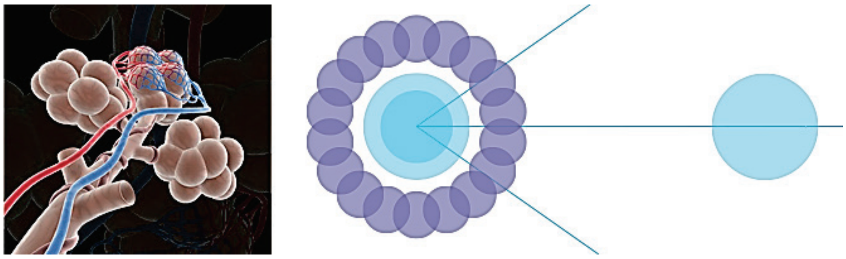
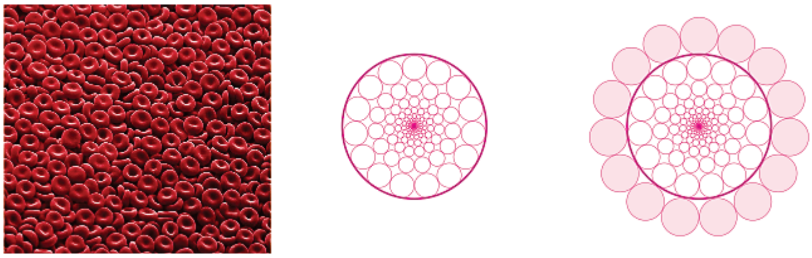
Figure 7. Blood oxygen, "Breathe" category



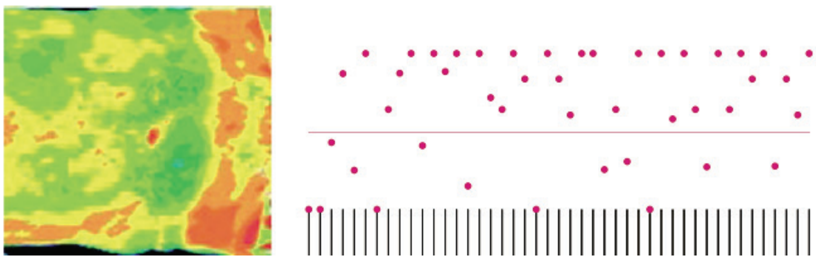
In the "Beat" category, the pulse rate is expressed by a circle (artery) that changes size according to the heart rate of a person. In this circle, which symbolizes the artery, there are little discs that correspond to the blood cells: when they go out of the circle, it expresses the pressure exerted on the inner artery wall. In this case, the person has high blood pressure.

Figure 8. Blood pressure, "Beat" category



The temperature is represented by red dots that are propelled from the bottom to the top of the screen. They move at an irregular speed until they stop and form a line. Depending on its position, relative to the reference line that symbolizes the normal temperature (in the middle of the interface), the person knows if he/she has a high temperature or not.

Figure 9. Temperature, "Beat" category.



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Conclusion

This paper aimed at highlighting the issues related to technological progress and the ageing population, especially in the health care domain. It does not claim to address all the design questions that may be raised, but to point out important challenges that, for us, must be undertaken.

Regarding ageing and diseases, technology has an important role to play and to this end, it needs to be embodied into holistic scenarios of use, which take into account the functional and cognitive heterogeneity inherent in the human being. However, a product can fully empower a person only when it allows him or her to take advantage of its actual performance, that is to say, when the perceived performance (user experience) is pleasant and does not compromise the actual one. However, especially in the field of health-related design, this consideration becomes even more important; a product actually endows its user with power when, beyond its practical and social acceptability, its design is sensitive and does take care of people's feelings (emotional acceptability). BlackberryAid, which corresponds to a one-month long research, has been presented as an example that supports this concern for a sensitive design in a context where the psychological dimension is crucial.

This paper focuses on the design of mainstream products for all, but the issues that have been brought up also concern specialized assistive products.

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REHABILITATION OF PATIENTS WITH MOTOR DISABILITIES USING COMPUTER VISION BASED TECHNIQUES

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Abstract: In this paper we present details about the implementation of computer vision based applications for the rehabilitation of patients with motor disabilities. The applications are conceived as serious games, where the computer-patient interaction during playing contributes to the development of different motor skills. The use of computer vision methods allows the automatic guidance of the patient's movements making constant specialized supervision unnecessary. The hardware requirements are limited to low-cost devices like usual webcams and Netbooks.

Keywords: computer vision, rehabilitation, skin detection, OpenCV, QT.

Introduction

Physical rehabilitation is often necessary after a person suffers an injury or illness. Via physical therapy patients are able to restore movement and strength through range-of-motion exercises. In standard medical practice physical therapists work with the patient until he or she is able to regain an appropriate functioning. However, a number of patient's remains with disabling chronic disorders that sometimes persist for the rest of his life and require continuous specialized treatment. Therefore, in physical rehabilitation the attention cannot only focus on finding a cure for the patient. Physical therapy should aim to maximize the potential physical, psychological and social abilities of the patients. The attention to persons with chronic motor disabilities is consequently a complex process that needs an approach from different points of view.

Physical therapy involves direct manipulation of muscles, joints and other parts of the body affected by an injury or chronic illness. Strength training, massage and supervised exercises, each one may be elements of physical therapy. Individual therapy regimens often depend on the type of injury or condition, the patient's age and specialized treatments prescribed by a physician. It is therefore a costly process in terms of resources and specialized personnel.

We propose the development of computer applications with low cost hardware where, through serious games, the patient is encouraged to perform rehabilitation exercises while at the same time its evolution is recorded. It is intended that these games, in addition to the therapeutic function, increase the patient's motivation to engage in their rehabilitation permitting a pleasant experience. The continuous need of supervision through therapist should also be avoided. Recent studies have shown that serious games help to motivate patient's rehabilitation (Rego, Moreira, & Reis, 2010). Serious games are video games that allow users to achieve a specific objective through entertainment. The current developments of computer vision, in either software or hardware, allow the acquisition and processing of large volume of data in real time using low-cost systems. Consequently the basic requirements for our applications are fulfilled.

The general idea is to capture the patient's movements through a web camera while at the same time he or she is displayed on screen in a modified environment. In this environment the patient will be faced with a representation of the rehabilitation goals in form of certain game tasks. These rehabilitation goals are defined by specialists and designed for the treatment and recovery of different motor skills.

The capture of the patient movement must be precise enough to allow an assessment of the development of their motor functions. It should be accurate enough to locate the joints of the patient’s body and the movement or changes of their relative positions. This requires the use of diverse tools and methods of computer vision together with other computational techniques such as those presented in (Jaume-i-Capó, Varona, & Perales, 2009) and (Jaume-i-Capó, Varona, González-Hidalgo, & Perales, 2010).

Tools for vision based game implementation

Considering the requirements related above, the combination of OpenCV (Bradsky & Haheler, 2008) and Qt (Blanchette & Summerfield, 2008) has been identified as the base libraries and platforms for the development of the applications. The first of these tools, OpenCV, is a cross-platform and open source library designed to achieve the efficiency required in real time applications with optimal use of hardware resources on Intel architectures. It contains hundreds of functions that implement various computer vision algorithms. Thus, it provides an easy-to-use infrastructure for deploying vision-based applications with certain level of complexity in short time.

Meanwhile, Qt, is a framework intended to create desktop applications whose code can be compiled on a wide range of platforms, from Windows 98 to Windows 7, Solaris, Mac Os, Linux and other less known. As a platform, it offers to developers design patterns implementations, visual controls and tools for quick user interface creation.

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Game overview

The games have been designed as simple applications with several abstraction layers. Several OpenCV tools are used to capture, transform and analyse images. The user interface is developed with QT. This design allows, in addition to an agile development, the adaptation of the functionality to different environment conditions under which the applications could be used. Depending on these conditions, different algorithms for human motion tracking can be used and the results properly analysed.

Games for patients with advanced mobility

Patients that are in an advanced state of recovery, can move superior joints more easily and require games with a more complex interaction that represent a challenge for them. Cognitive elements should be added to these exercises in order to improve the motivation and influence the integral rehabilitation.

In applications implemented as part of this research, physical exercises and simple activities such as link object images with their names, order the letters of a word or touch a target on the screen in a period of time should be combined (see Figure. 1).

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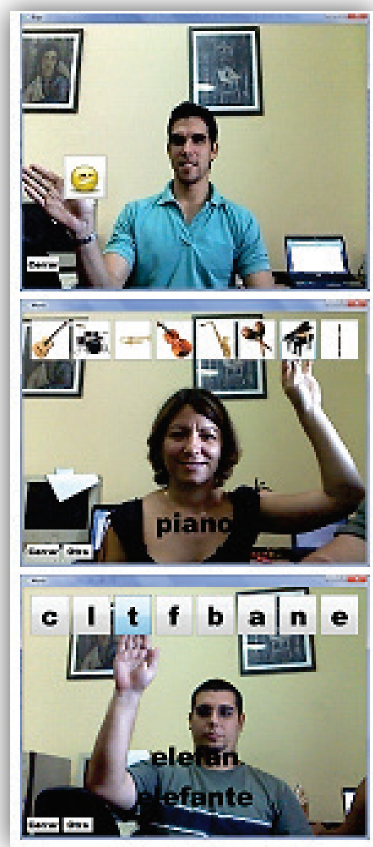
Figure 1. Exercises for patients with advanced mobility. Source: University of Havana.



All the interaction in these games is managed through skin detection. Possible skin zones are detected in the images taken by the web camera. Skin detection is performed using simple algorithms that classify points regarding their chromatic properties (Vezhnevets, Sazonov, & Andreeyea, 2003). In most cases, these algorithms are efficient enough to be used in real time processing, but they need controlled lighting conditions in the environment and a background color that does not interfere with the analysis (see Figure. 2).

Figure 2. Skin Detection under different conditions.Source: University of Havana.

Games for motion instauration

In the first stages of rehabilitation, motion of affected joints is null or almost null. The main challenge for specialists at this point is to encourage a patient to make a movement, even a tiny one. Exercises used for this porpoises are called *ideomotors*. The patient receives an order that can be verbal or any other type and is recompensed if they achieve the goal. Some of the applications developed are aimed to improve this stage of the treatment, specially the shoulder motion instauration (see Figure 3).

Figure 3. Example of excersises for shoulder motion instauration. Source:University of Havana

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In these games, the patient sees themselves on the screen and receives instructions to make a movement. Once the order is given, the application records information about movement appearance, amplitude and repetitions. Flexion and abduction are some of the types of movements this therapy works on.

All the interaction is implemented through markers made of colored papers that can be done by the family of the patient with a low cost, in contrast with the price of infrared markers traditionally used in this kind of treatment (Huiyu & Huosheng, 2008).

One of the remarkable aspects to take account during the development is the inertial or involuntary motion due to patient's handicaps, for example, in patients with Parkinson.

Game validation

Various factors such as efficiency, effectiveness, and satisfaction with the use of the applications by patients and therapist have been taken into account in the validation of the games.

For this validation control measures appearing in Manresa (Manresa, 2009) and others, in terms of usability, of the international standard ISO 9241-11 were considered.

Starting from requirements analysis we designed a database system to include all the information necessary for the final evaluation of the applications.

The validation phase is carried out with different groups of patients with movement disorders to them surveys are applied to measure the level of satisfaction before and after recovery. This phase also takes into account the comments of patients and therapist to improve the functionality of the games. The preliminary results allow to affirm the feasibility of the procedure.

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Conclusions

Vision-based applications with interactive games for the rehabilitation of patients with motor disabilities promise to be an effective way to contribute to their social reintegration. The games that are already implemented are in long-term validation phase, but the preliminary results allow us to assure the feasibility of the procedure. High-cost hardware is not required to develop the games; this fact facilitates the spread of this technology over distribution of the software.

The use of more advanced techniques of computer vision, such as optical flow, allows us to improve and adapt the games to more general environments, which is a field of active research.

Acknowledgments

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USE OF ROBOTICS AS A LEARNING AID FOR DISABLED CHILDREN

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Abstract: Severe disabled children have little chance of environmental and social exploration and discovery, and due to this lack of interaction and independency, it may lead to an idea that they are unable to do anything by themselves. Trying to help these children on this situation, educational robotics can offer and aid, once it can give them a certain degree of independency in exploration of environment. The system developed in this work allows the child to transmit the commands to a robot. Sensors placed on the child's body can obtain information from head movement or muscle signals to command the robot to carry out tasks. With the use of this system, the disabled children get a better cognitive development and social interaction, balancing in a certain way, the negative effects of their disabilities.

Keywords: Learning support, disabled children, educational robotics.

Introduction

Learning in childhood is done by exploration and discovery of the environment where the child lives. According to Piaget's definition, up to the second year of life the child is living the sensorial motor period (Thomas, 1992). During this step of development, interaction with the environment is done through physical sensation and body stimulus (Linder, 1990). This idea means that they learn how to interact with their own body as well as the environment by repeating experiences and exploring the world through their senses. At the end of this sensorial-motor period the children has the notion of space, position of objects inside the space and time, and some relation among them (Cook & Howery, 1998).

This spatial object manipulation and environmental interaction are fundamental for the child cognitive development and the ones with severe disabilities are blocked from experiencing the world as the other children do. With this situation they may become delayed in terms of learning through exploration by themselves.

Considering this lack of independency, exploration and spontaneity on discovery of the environmental area around the child, those ones can have a negative influence towards learning and social interaction. All this situation of lack of stimulus can produce a late childhood (Cook & Howery, 1998).

Due to these body-limitations, disabled children are, usually, very dependent on their parents or caretakers to interact with the world. Researches from Brinker and Lewis suggest that the child’s behavior can, by itself, determine which experiences their parents and caretakers would allow them to have. These choices may restrict even more the cognitive and social development of the infant.

This entire situation can create a lack of interest of exploration and consequently also develop the idea of learned helplessness, which they see themselves as unable to do anything independently or without external help. With this idea the child usually adopts a passivity and lack of interest behavior towards the world he or she lives.

All these elements can compromise the behavior, as said before, once they become socially passives and dependents. To minimize this, it is necessary that the child has a way to explore the world, through alternative methods and according to what the child has to develop (Scherzer & Tscharnuter, 1990). Doing this is very likely that this child can have a better motivation and interest, giving them an opportunity to explore independently (or at least less-dependently) the world which they live. Finally, the idea of learned helplessness can be minimized and the self-esteem grows up (Todia, Irvin, Singer & Yovanoff, 1993). Figure 1 shows how the learned helplessness occurs.

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Assistive Technologies have been providing to these severe disabled children a certain degree of environment control by themselves (Cook & Howery, 1998). This helps to take out the idea of learned helplessness, as shown in Figure 2.

According to Swinth, Anson & Deitz, children since their six-years old already have the ability to access and cause and effect computer software by pressing a key.

Figure 1. Generation of learnied healpless idea in disabled children.

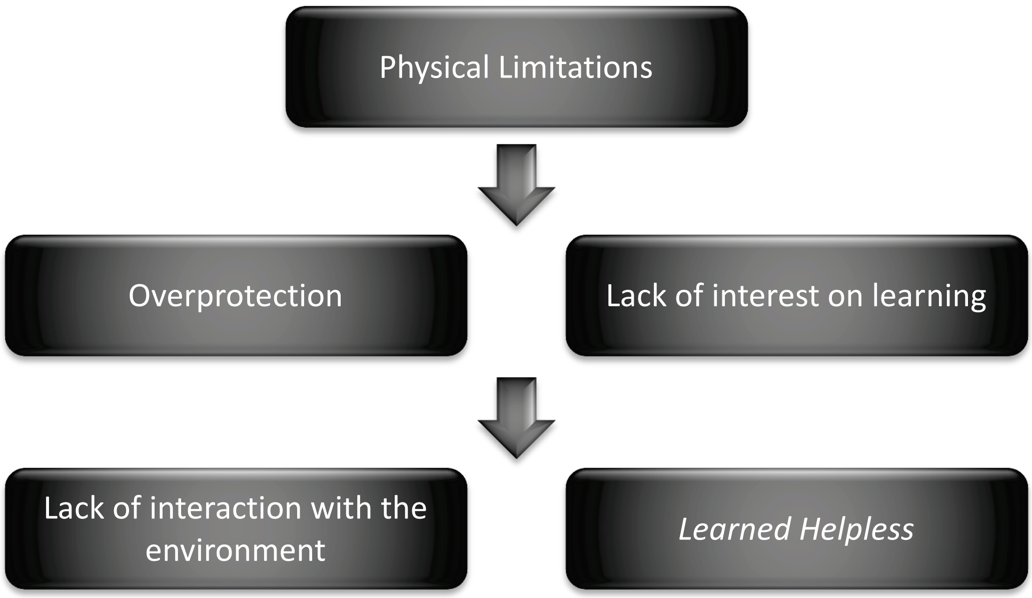
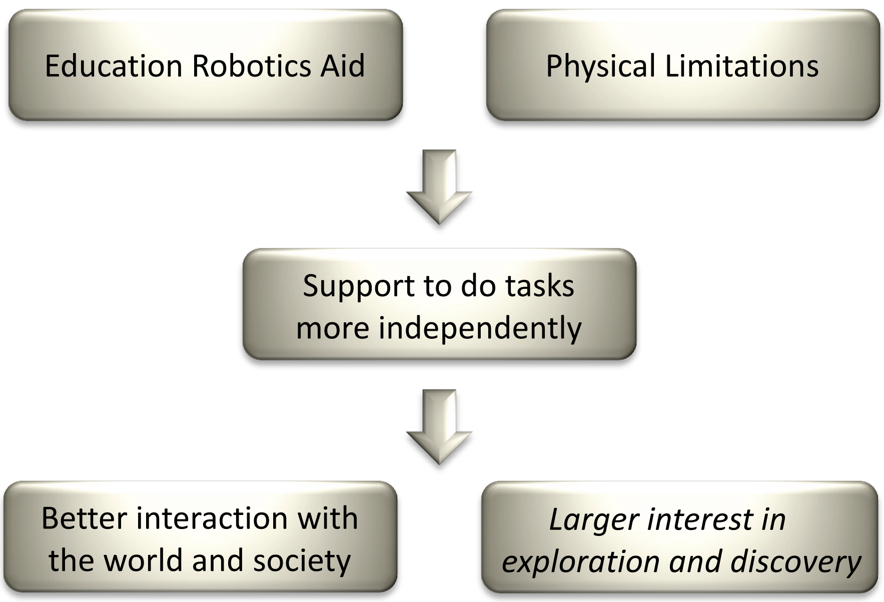


Figure 2. Robotics support used to help blocking the learned helplessness idea.



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Thus, assistive technology and robotics can provide to these disabled children a unique opportunity to choose how they will interact with the environment and can also give a certain degree of control. So it is given to them the opportunity to choose what they will experiment, instead of experimenting only some tasks already designed for them (Cook & Howery, 1998). Furthermore, robotic system also provide control over three dimensional object manipulation, which is a more real situation compared with the two dimensional graphics provided by simulation with computer software, so the interaction can also be more realistic (Cook & Howery, 1998).

Several researches were done to determine if very young disabled children could interact with a robotic manipulator (Cook, Hoseit, Liu & Lee, 1988). Nine children took part of this research, being six with a disability and three without any. Everyone in this group of nine was less than 38 months of age. The system was, basically, a computer to control and acquire data connected with a small robotic manipulator (Cook et al, 1988). The manipulator was used by those children as a tool, once they can use that to bring to them objects (Gu, Cook, Meng & Dong, 1997).

In that study, fifty percent of the disabled children (all with cognitive age older than seven months) and all non-disabled children interacted with the robotic manipulator, using it as a tool, to catch an object that they could not reach. It was also observed that the cognitive and linguistic level of the children were higher than the motor level (Cook et al, 1988).

Later, this previous research was complemented, always focusing on exploration and discovery of the environment by the children. The new goals were (Cook & Howery, 1998): evaluate how severe disabled children could use the robotic manipulator for exploration and define the relationship between the keys pressed and the task complexity.

This research has shown the way three years up to six year-old children use the robotic manipulation for environmental exploration (Cook, Max, Gu & Howery, 2002). The same research was done analyzing how child behave when they could have access to a variety of movements through one or more keys, using the robotic in a discovery and exploratory way (Cook et al, 2002).

A complex progressive sequence task series was held and it was noticed an increase of cognitive development of those children. Consequently, as the task got more difficult, it was needed more pre-programmed keys to achieve the desired goal (Cook et al,1988; Gu et al,1997; Scherzer & Tscharnuter,1990). It was presented to the child how the manipulator moves using each key; showing the previous movement to them and encouraging them to use the system (press the keys) (Cook, Hoseit, Liu, Lee & Zeteno, 1998). To maximize the results of those experiences dry macaroni inside a box and a glass were used. The task goals were:

First, the robotic manipulator should let the dry macaroni falling from the glass (where the dry macaroni were at first moment) by pressing a key just once;

Next, the child controls the robotic manipulator in order to fill the glass with the dry macaroni. The child gets the macaroni; put it inside the glass by letting it falls from the robotic manipulator, which is located above the glass;

Finally, and the more complex task of these test, is the overall sequence. First the child should get the macaroni from the box, put inside the glass and let it falls inside the box again. This must be done by using three keys.

Each one of these experiences were videotaped for further revision (Cook et al,1988; Cook et al,1998; Cook et al, 2002). The research observations included the child's action and its behavior during task accomplishment. For such example, it was observed how and who or what the child was looking during the tests. Behavioral signals were also included such as fear, happiness, if the child is smiling or crying, boredom or joy. This was registered before and during the use of robotic manipulator, so they could evaluate psychological aspects towards the experiment. Fortunately it was detected great happiness using the robotic manipulator, instead of fear (Cook et al, 1988).

It was also observed that child can respond longer times using robots instead of 2D computer software (Cook & Howery, 1998). In those tests, it was also realized that the child could understand what each key can do by demonstrating its function previously. High interest about the tests was observed when child looked towards the robot or the keys, proving they were interested on doing that (Cook et al, 1988).

This study complemented the previous works of the same authors, once it focused on the child's understating about the system.

An important issue is the robot's design. Tests done with autistic child has shown that the robot should be seen as a toy and must be friendly and good-looking (Michaud, Clavet, 2001). As related in (Werry & Dautenhahn, 1999) those child must feel comfortable and safe with the robots, instead of felling fear of them. Some properties as the robot speed and robot's appearance should be carefully analysed (Werry & Dautenhahn, 1999).

Although those articles cited previously (12, 13) is about autistic children, the idea of the appearance of the robot can be applied to the disabled child, once the child must feel comfortable and safe with the robot. Other important thing is that tasks must be very joyful for those children, once boredom tasks often discourage them to use the system.

In autistic children the robots are used for better interaction, trying to take them out of their "own world" and bringing them to the "real world". In the case of the disabled children the idea is to amplify their experiences inside the "real world", increasing their contact with new and self-controlled experiences and consequently reducing the learned helplessness idea. So, some ideas can be used in both scenarios, although the two situations are completely different.

Methodology

In our researches, we have used a mobile robot with tweezers for manipulation of objects. This robot is commanded by disabled children using some of their voluntary signals.

Several tasks were done by those children, always focusing on environmental interaction, taking objects and finally putting them off on another place, finding "hidden" objects (actually an object among others with some degree of complexity to find), and drawing on a paper located under the robot.

All sessions are videotaped for further revision (after the parents signing the Consentient Term, approved by Ethical Commission). With the video, child's actions (such as number and order of keys pressed necessary to complete,

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with success, the task), and behaviours during the experience are evaluated by a Pedagogue.

Goal Attaintment Scale (GAS)

In order to measure the success of the trial executions, that includes emotional aspects, the Goal Attainment Scale (GAS) (Cook, Bentz, Hartbottle, Lynch & Miller, 2005) is used. GAS is a method that has a score which, in addition to evaluate statistically the data, takes into account aspects like fear and happiness when the child is carrying out the trial, putting a score if the trial was executed or not and how it was executed. On the other hand, the GAS method allows including results from interviews with parents, teachers and caretakers who are able to evaluate improvements in the cognitive aspects of the child when using the robot.

GAS is also known like “Goal Achievement Scale”. This method uses different weights to the goals attained in addition to a grade to each goal. The total grade may vary between -2 to +2, where 0 is the expected result, positive grades are results better than expected and negative grades are results worse than expected. It’s worth to comment that this scale has high subjectivity level because it takes into account the disabled level of the child.

The global grade is calculated according the grades obtained for all goals accomplished. Equation (1) shows the overall score (Cook et al, 2005):

$$T = 50 + 10 \cdot \left(\frac{\sum_{i=1}^{n} g_i}{\sqrt{n\text{-}R \cdot n + R \cdot n^2}} \right) \qquad (1)$$

Where:

- gi – grade related to the goal i accomplished by the child.
- n – number of goals accomplished for each tasks (one task can have several goals. The partial accomplishment is also taken into account).

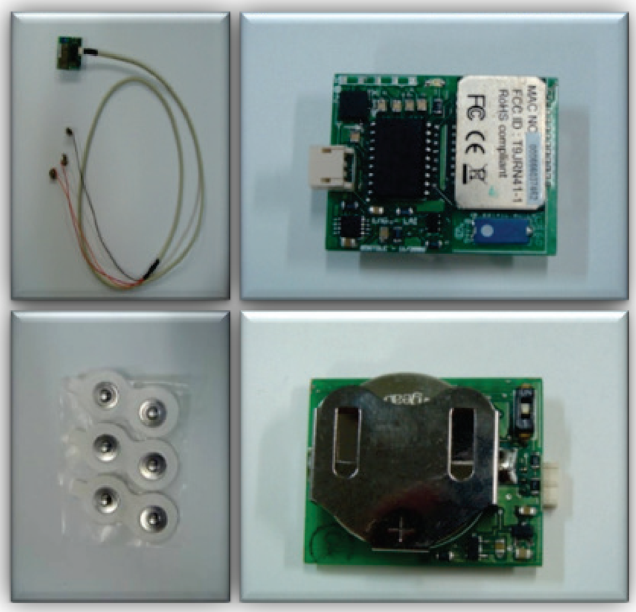
- R – constant used to estimate the correlation between the grade and the several goals in the tasks. A constant of 0.3 is used, in the same way of (Cook et al, 2005).

Equation (1) should be used in a comparative way, according to (Cook et al, 2005), i.e. it should be verified the improvement obtained in several trials after the execution of the first trial. This way, it is possible to evaluate the improvement in terms of learning and grades (which measure how many goals are accomplished), thus having a way to measure the cognitive improvement of the child.

Hardware and Software

As part of the hardware used in this work, a sensor to capture both inclination of some part of the child body and his/her muscular effort (sEMG signal) was developed. Figure 3 shows the sensor developed, which has a battery and a Bluetooth transmitter included. The information of inclination is obtained from an accelerometer and the muscular effort is obtained from surface electrodes. Both data are transmitted to the robot which is used to execute movements and open or close its tweezers.

Figure 3. Sensor developed to capture both inclination of some part of the child body and the muscular effort (sEMG signal).



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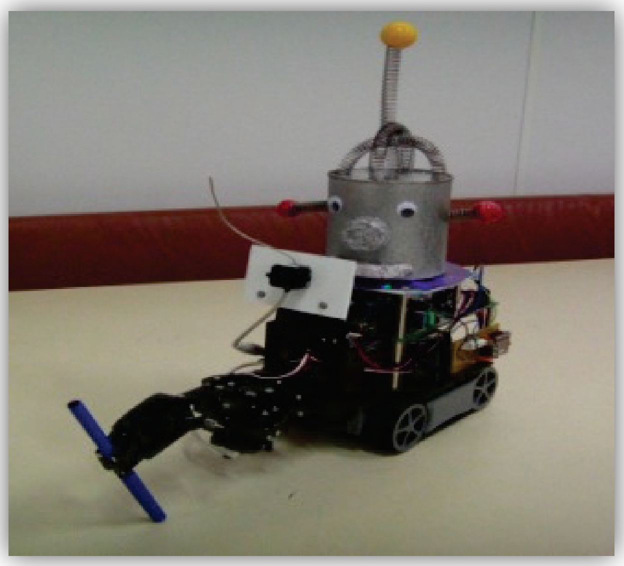
The mobile robot used in this research is the POB-EYE, manufactured by POB TECHNOLOGY. It is a mobile robot with tweezers which allow using the robot as a manipulator robotic as well.

In order to change the appearance of the robot, a clown mask was adapted to the robot as shown in Figure 4.

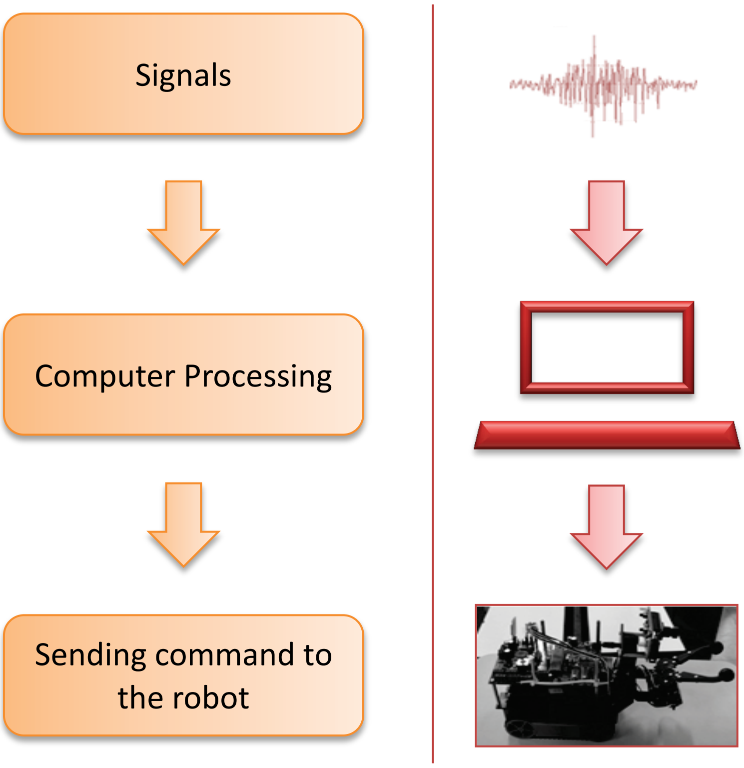
Figure 4. Robot used in this research.



Once the sensor acquires signal inclination of the body part and muscle effort from the child, that information is sent to a PC which processes the signal and makes an interpretation about which kind of action the child wishes the robot executes. So the movement order to move (or stop moving) or open or close the tweezers is sent to the robot. All the communication is done through Bluetooth devices.

While the computer is processing the signal to command the robot, the computer also makes a report recording each movement done, including time, picture of the child's face in the moment of the movement and number of the movement. If there's a correct sequence pre-programmed the report also shows if the movement is right or wrong. In this "correct sequence mode" the robot only executes action in correct movements. All this data is important for further evaluation by a Pedagogue. Figure 5 shows the scheme of the system.

Figure 5. Scheme of the system used to capture the signals and to command the robot.



According to the child's head movement the robot can drive ahead, backwards, to the left and to the right and other soft movements between those four main movements. To make the tweezers' movements it is necessary to use the EMG signal, so it is possible to switch the state of the tweezers.

On the other hand, the accelerometer's signal is received continuously and its value is converted to an angle which defines where the child wants the robot to go.

Limits values (maximum and minimum) are defined and are, actually, the highest and lowest inclination in each axis. It is done throughout two axes, so it is possible to calculate the angle between them.

Each value sent by the inclination sensor is a number that will be used by the software to understand where the child wants to move the robot. Firstly, it is analyzed the vertical axis (front and back) and later the horizontal axis (left and right), which means that the vertical axis is predominant. So if the

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inclination is diagonal being front and right the robot will drive ahead, not to the right. This allows the execution of soft movements with participation of the two axis, which means that the robot will go in the diagonal direction.

The signals sent to the robots are, actually, characters which indicate what movement it should do. Those characters are “w” for driving ahead, “d” for driving to the right, “a” for driving to the left and “s” for driving backwards. There is also the signal used to stop the robot that is represented by the character “t”.

The same idea is done with sEMG signal, which has a threshold trigger value to order the robot to switch the tweezers’ state.

Thus, when the robot is on a blank paper and has a pen hold by the tweezers, it is possible for the child, with some training, to draw something on the paper.

Computer Interface

The computer interface was developed to help the evaluator and the child to achieve the goals. It resumes all the data of the tests and allows adding robots, tasks, children and auxiliary devices inside the database. It also allows searching for reports. The main screen of the program is used to better conduct the tests, once it shows all important data to the test achievement.

This computer interface can be divided, basically in six areas: main tasks, task registration, reports, children registration, robot registration, auxiliary devices registration.

The main screen is the task screen, which resume all the important data for the test achievement. It also allows the control and access of all the other parts of the program. It is necessary, before starting the test, to select a child’s name, a type of test, and a robot. It is also necessary to select a camera and the communication ports of the auxiliary device and robot. The screen is shown in the Figure 6.

Figure 6. Main screen of the system.

The child's name, robot and task is previously registered in the software database. Such information is very important once it is used to make the report.

Connection ports of sensors and robot are defined inside this part of the program. As said before, it is necessary to select a COMM port to allow communication for the robot and another one for the sensor. If the COMM port for the robot is left blank or it is not possible to communicate with, there is the option of executing the trial using the virtual robot, represented by a little yellow circle, showed on the screen. On the other hand, if there is no sensor the virtual joystick in this screen can be used as a virtual auxiliary device. The system scheme is showed in Figure 7.

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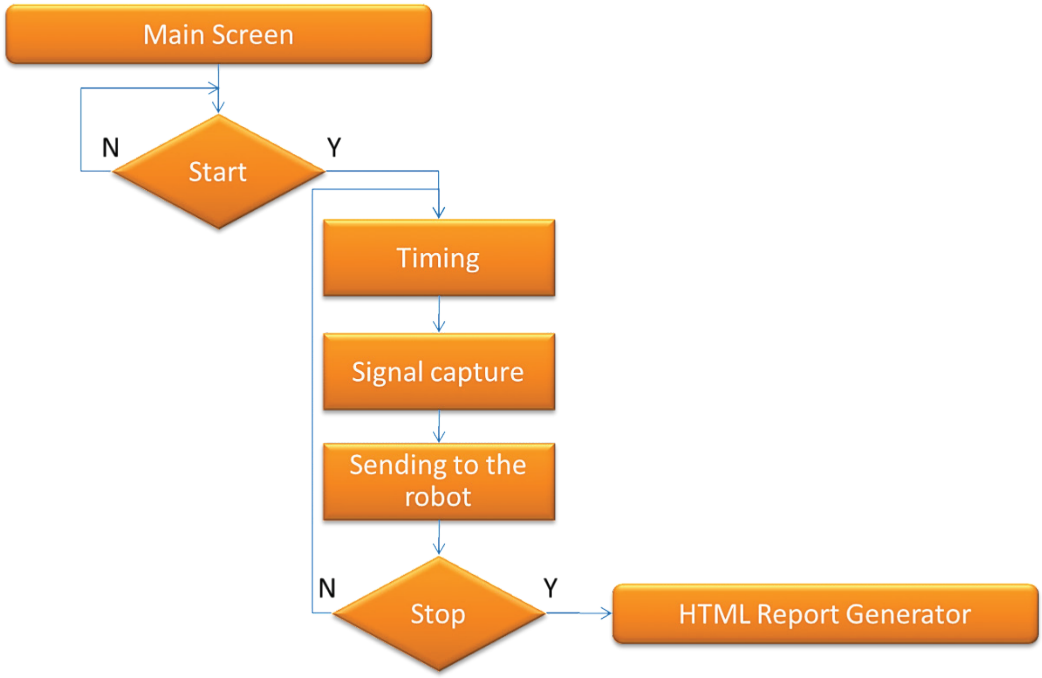
Figure 7. Simplified flowchart of software operation.



This scheme considers that a child, a test, a robot and a camera have been previously selected. If not, the system will show a dialogbox asking for choosing what is missing. Other important thing is that inside the block “send to the robot” there is a process that will be explained further. In the system “start” and “stop”, showed in the above diagram, are, actually, the green and red buttons of control’s groupbox.

Inside this screen there is a link to “right sequence”. This part of the software allows the evaluator to choose the correct movements and the robot only will do the movement when it is correct. Wrong movements will be registered and can be used to evaluate statistically if the child has adapted well or not to the system.

Automatic Reports

After executing the trials, a report is generated, including the child’s name, the test name, the robot name, the duration of the task, the number of movements and the pre-programmed sequence, if there is any.

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The list of movements done is also presented in the report. This list contains the number of the movement, excluding the movements ordering the robot to stop. Together with the number of the movement there is a picture of the child that will be followed by an arrow showing which movement the child did.

If there is no right sequence, those arrows will appear blue. It there is a right sequence, those arrows will appear green when the movement is correct and red when the movement is wrong.

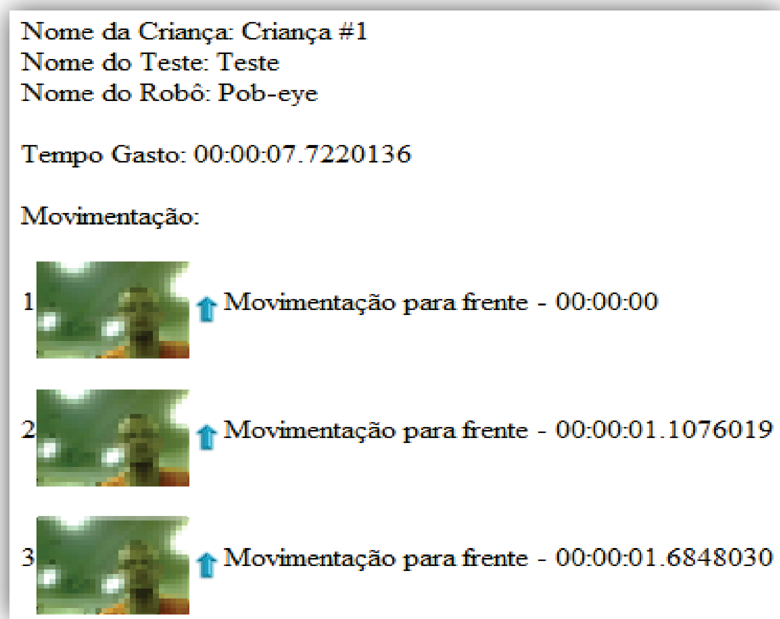
Following the arrows (any kind of them) there is a little text that says the direction of the movement and finally there is the movement time, compared with the first movement (the first movement is considered to be at moment zero).

When the system is in “right movement mode” it is possible to calculate statistically the system’s efficiency.

All this report is done to further be possible an evaluation by a Pedagogue. The pictures are very important to evaluate the emotional state of those children by looking their face expression, such as smiling or crying. Those elements are, certainly, very important, once it can make severe influence on the trials.

With some reports of those children it is possible to evaluate if they are or are not getting used to the system and if there is an improvement in behavioural-cognitive terms. A report example is shown in Figure 8.

Figure 8. Report generated with the software.


Nome da Criança: Criança #1
Nome do Teste: Teste
Nome do Robô: Pob-eye

Tempo Gasto: 00:00:07.7220136

Movimentação:

1 Movimentação para frente - 00:00:00

2 Movimentação para frente - 00:00:01.1076019

3 Movimentação para frente - 00:00:01.6848030

Supporting the main part of the program there are the registration part (of people, robots and auxiliary devices) and the report screen.

Those registrations work similarly. They are connected to a Compact SQL Database included in Visual Studio Express Edition 2008 installation. Each registration screen has its own database.

Registration and data conversion

In the child register some questions are asked, such as child's name, birth date, which kind of disability the child has and the parent's name. In the tasks registration just the name of task and a brief description is asked. In each case there is a unique identifier to ease the organization and searching.

In the registration of robots and auxiliary robots some more information are asked, which are very important, due its use in the translation between the auxiliary device signal and the robot signal. In other words, in those parts of the programs it is asked which signal is received when it is wanted to drive ahead, backwards, left or right. So the database knows previously which signal represents each action.

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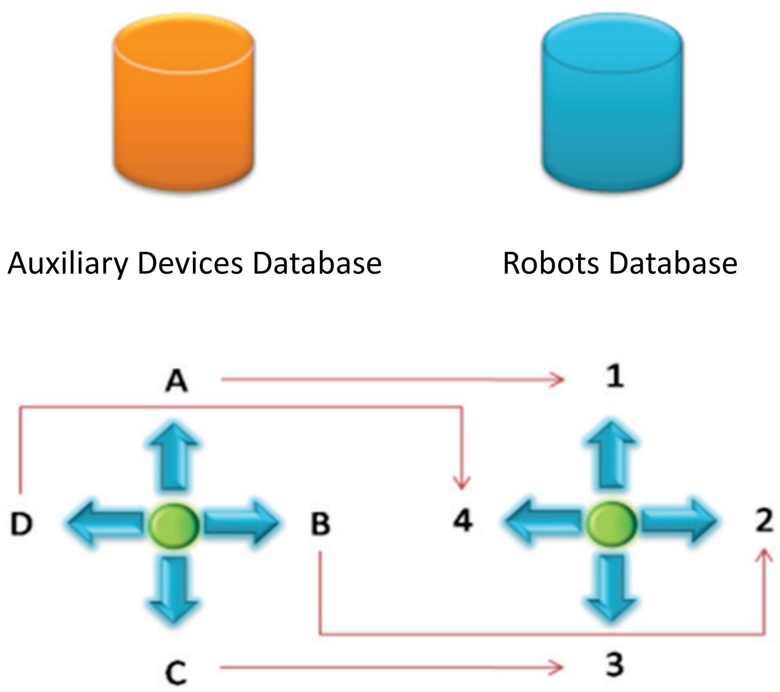
At the same time, the robot registration asks which command the robot should receive to do certain action (such as driving ahead, backwards, left and right, changing of the tweezers mode). So the software catches the signal of the auxiliary device and “translate” it to the robot. Hence, using this system, virtually any auxiliary device compatible with any robot can be used to perform the tasks. This idea is shown in Figure 9.

Figure 9. The correlation between the commands is done comparing equivalent items in different databases.



To illustrate this, a child would be able to control the robot with any sensor. And on the other hand with one sensor he or she can control any robot (if it is compatible).

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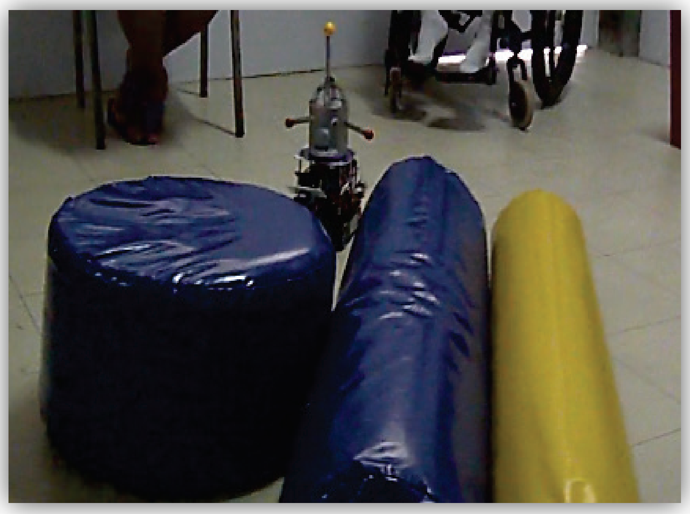
Tasks

In order to evaluate the system developed, three tasks were performed by 14 disabled children along three weeks. The duration of each task was about 30 min. The tasks were:

- Initial Task (Training) – Move the robot through a path with obstacles. This task allows the children have the first contact with the robot and it was necessary to command the robot in four directions. Figure 10 shows a picture of the initial task.

Figure 10. Initial task (Training) with the robot.



- **Task #1 - Drawing with the robot.** In this case, the robot has a pen hold by the tweezers and the child should command the robot to move on a paper in order to draw lines (Figure 11). In this work, the ability of making free drawing was also evaluated (Figure 12).

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Figure 11. Drawing a path with the robot.

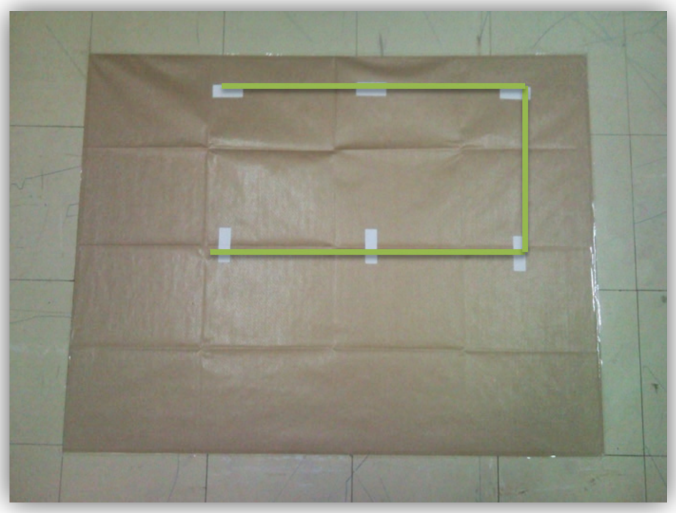
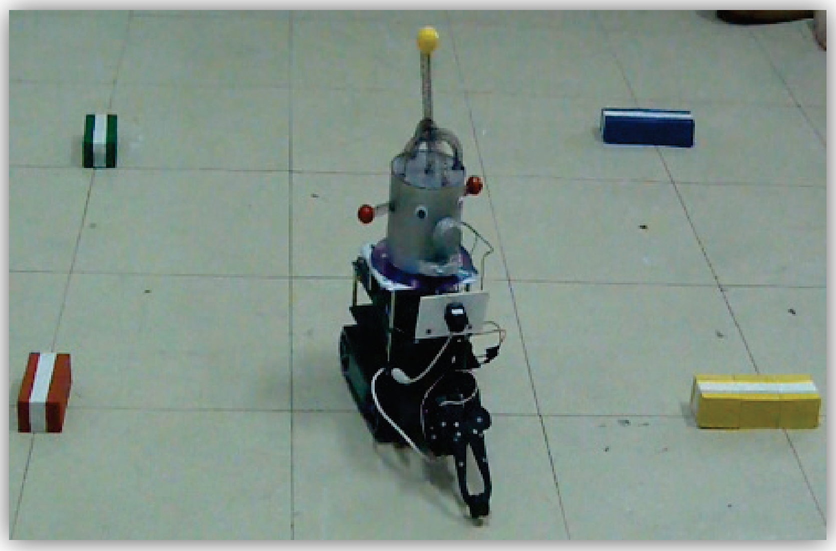


Figure 12. Free drawing made by a disabled child.

- **Task #2 - Command the robot through more complex paths.** In this case, the path contains some color blocks used as obstacles. The free space to move the robot is reduced which demand more precise movements. Figure 13 shows this task.

Figure 13. More complex path.



Results

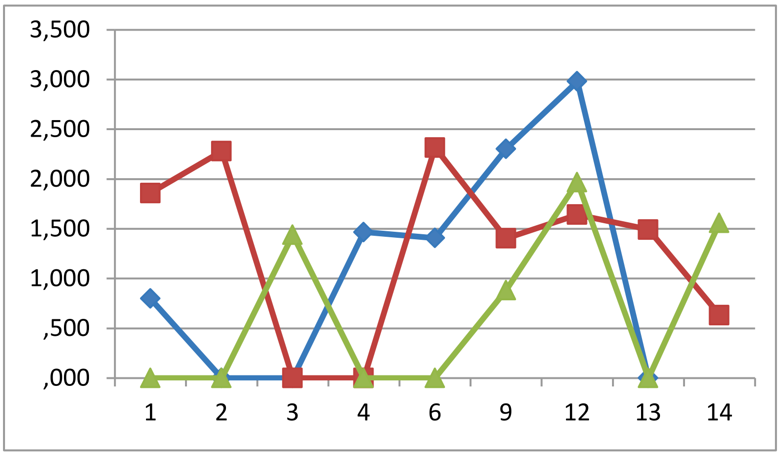
Several trials were carried out with 14 disabled children and it was possible to evaluate the results based on some aspects like time to finish the task, total number of movements executed by the child, number and percentage of movements that produce robot movements (valid movements), and movements by second. This evaluation was carried out after several weeks in order to find out the improvements obtained with the use of the robot to aid these disabled children.

From these aspects, movements by second and percentage of valid movements seem to represent the more important ones, because the number of movements by second trends to diminish according to the repetition of movements with the robot made by the child. In fact, according to Table 1 and Figure 14, the number of movements by second decreased from the first to the third week, although there was an increase of these movements in the second week because in that week there was a different draw carried out by the children, needing in that case higher number of movements by second.

Table 4. Number of movements by second.

Child	Week 1	Week 2	Week 3
1	0,80	1,86	-
2	-	2,28	-
3	-	-	1,44
4	1,47	-	-
6	1,41	2,32	-
9	2,30	1,40	0,88
12	2,98	1,64	1,97
13	-	1,49	-
14	0,63	1,56	-
Average	**1,60**	**1,79**	**1,43**

Figure 14.Movements by second during three weeks.



In relation to the percentage of valid movements, Table 2 and Figure 15 show the increase of this parameter along the weeks, which it is expected due to the confident of using the robot by the children.

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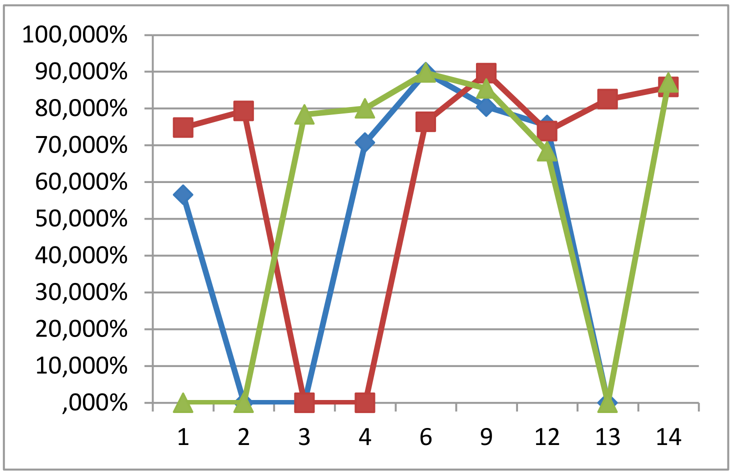
Table 5. Percentage of valid movements.

Child	Week 1	Week 2	Week 3
1	56,53%	74,78%	-
2	-	79,30%	-
3	-	-	78,37%
4	70,69%	-	-
6	89,81%	76,35%	-
9	80,43%	89,58%	85,41%
12	75,43%	73,85%	68,38%
13	-	82,49%	-
14	85,80%	87,01%	-
Average	**76,45%**	**80,48%**	**77,93%**

Figure 15. Percentage of valid movements.



Conclusions

The main goal of this system was to increase the communication between the child and the external world. It consequently will bring a better learning and a better social interaction as well, which are important elements for human development.

All the system was evaluated successfully with 14 disabled children during a sequence of trials they performed.

From Table 1-2 and Figure 10-11, it is possible to find out that the children improved the learning of using the robot, which is verified comparing the number of movements by second executed along the week (decreasing of 10,6%). On the other hand, the number of valid movements also improved along the weeks (about 4%).

Using the results of the system's reports, it was possible to change and create new tasks in order to try to make those children interact even more with the environment, bringing them more independence and self- esteem.

Future works with this system include the use of this playful robot in different therapy with disabled children. This system helps also the execution of movements by these children in the field of Physiotherapy because children feel stimulated to move parts of their body when realize that their movements can command a robot.

Acknowledgments

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ROBOTICS FOR SOCIAL WELFARE

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Abstract: Supported by developments in the field of social robotics, virtual worlds and ICT tools it is possible to build new solutions in health and welfare. Two projects are described in this article. They are intended to improve efficiency and quality of current therapeutic procedures. The ESTIMULO project improves emotional and cognitive status of people with dementia using a reactive pet-robot. The ELDERTOY project modifies the classical concept from the toy industry to develop a new solution for the aged people. ELDERTOY involves a double purpose, fun and therapeutic. In a complementary way, these projects aim to be an example of the breaking of the technology gap both of seniors and of people with disabilities. Therefore, the ultimate goal is to promote and adapt scientific and technological knowledge to be applied to improve significantly the standard of quality of life in society.

Keywords: Social robotics, Therapy, Dementia, Well-being, Cognitive stimulation.

Introduction

European population lives longer than ever thanks to economic growth and healthcare advances. Average life expectancy is around 80 years, and in 2020 about 25% European population will be 65 or more [1]. The increase in life expectancy supposes in many occasions the development of illnesses associated with old age, among them senile dementia [2].

The most common causes of dementia in the European Union are the Alzheimer disease (about 50-70% cases) and multi-infarct dementia, due to repeated brain infarcts (about 30%). Other relevant causes are Pick's disease, Binswanger encephalopathy, and dementia with Lewy bodies [3].

Regarding the clinical evolution experienced by patients with dementia, criteria have been established to determine the level of its intensity [4]. It is convenient to point out that not all pathologies evolve in the same way, and that in patients with the same diagnosis the disintegration of mind functions does not follow necessarily the same pattern.

The European Commission acknowledges the potential in ICT to help elder people to cope with isolation and loneliness, to better access social and commercial services but, above all, to maintain personal independency for longer.

Ageing consumers are not always taken into account in the design of products of common usage, and it's necessary for the industry to be more conscious about the abilities of senior consumers.

For instance, 21% of people 50+ years old have severe audition, sight or manual dexterity problems, so it is difficult or impossible for them to employ standard ICT equipment. It is for this reason that is unavoidable to adapt ICT to the needs of all people.

In the present paper two R&D projects are described, both centred in researching the possibilities that the new technologies offer us to enhance life quality of elder people suffering dementia.

Both projects generate an added value and innovation for conventional cognitive stimulation therapies [5]. Those are based in the plasticity character of the brain (known as neuroplasticity), that is, the response of the brain after damage, to adapt itself to the new situation and restore the altered equilibrium.

Several researches show the ability of damaged neurons to regenerate and establish new connections. This is the case also in the aged brain, even those with dementia, though with less intensity. Given this brain capacity, there exists a basic concept for the treatment of dementia: That of psychostimulation [6].

This term refers to “the set of stimuli generated in interventional neuropsychology aimed at rehabilitation”.

Cognitive stimulation techniques include exercises consisting in the presentation of stimuli, resulting from due study, that pretend to maintain or recover cognitive functions, exercising existing and altered abilities. It is in this point where the ESTIMULO and ELDERTOY projects show all their potential.

In the moderate and severe phases of dementia, neuroplasticity will be strongly limited, due to the high proportion of damaged and/or dead neurons, resulting in a diminution of the synaptic processes implied in learning. In these situations, cognitive stimulation is harder. In this stage, the ability of the patient to perceive the environment and to interpret reality is affected, constituting an important source of stress hard to mitigate, given that the causes cannot always be modified, and frequently the deficits of the subject prevent the therapeutic action.

In this context, the first of the said projects, ESTIMULO, has as a goal to enhance patient-carers interaction. On the other hand, in the ELDERTOY project, a therapy tool is built for 60+ aged people, with a shape and appearance resembling a toy. From the point of view of therapists and gerontology specialists, the results of both projects are useful as ICT tools on which to build individual and group workshops and games. The ultimate goal of these workshops is to stimulate the abilities of users and mitigate the cognitive worsening in the phases of dementia.

The structure of this paper is as follows. 2) The ESTIMULO project, in which details are given on the goal, scope and results of the project; 3) The ELDERTOY project, describing the singular aspects of this action and the benefits on people's life quality achievable by means of the ELDERTOY development platform; 4) Scope of application, describing the set of techniques supporting cognitive stimulation therapies involved in both projects; 5) Technology tools, treating in depth the ICT tools employed in the several cognitive stimulation workshops; 6) Conclusions and further work; 7) Acknowledgements; 8) References.

The ESTIMULO project

For long years therapies including animals have been employed for the enhancement of the emotional and cognitive state of people with dementia [7]. The work with animals as applied to the medical treatment of people has been amply used in hospitals and in retirement homes. Works with animals are developed in two phases, animal assisted therapy (AAT) and animal assisted activities (AAA) [8].

Animal assisted therapies have concrete therapeutic goals, jointly defined by doctors, nurses, psychologists and therapists. On the other hand, in animal assisted activities the interaction between patients and animals lack specific goals.

Though the usage of animal assisted therapy has produced important results, almost all hospitals and retirement homes have dispensed with this kind of therapies due to the possibility of allergies, infections, biting, scratches, and generally the fear that certain kinds of animals can cause to the patients. Other counterproductive effects [9] resulting from animal assisted therapies are related to the sentiment of sadness arising in case of the death of the animal in the course of the therapy. After the strong affective and emotional bond ensuing during the activities, the loss of the animal can produce a strong affliction and sadness feelings in the patients.

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In the ESTIMULO project work is done with a pet-robot and with multimedia audiovisual content projection, all easily replaceable for others of similar features, in case of damage. So, the problems arising from the loss of a living being proper of animal assisted therapy, as also the problems of their disinfection, are avoided.

The therapy tools used in ESTIMULO open a new therapist-patient interaction paradigm, in offering a stimulation channel adapted to the involution model of the patient in the moderate to severe stages of dementia. In these stages, there is a loss of the ability to accomplish concrete operations, but it persists that of making exercises with real objects, moreover if they have an emotional implication. Their recognizable physical qualities are also a relevant feature in these stages, because the recognition ability is maintained by the individual.

Figure 1. PARO Seal

The usage of systems such as PARO (the pet-robot shown in Image 1) as a tool on which to build new therapies applied to people with dementia has, as its main purpose, the generation of a feeling of relaxation and pleasure in the patient. This fact will unleash the enhancement of cognitive and interaction abilities of patients with their surrounding world. This way, we can achieve that the patients become more active, receiving and communicating among themselves and with the clinical care people.

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The main goal of the new therapies pursued in ESTIMULO is to produce three effects in patients with dementia:

- Psychological effect. Resulting form a better relaxation and motivation due to the activity realized.
- Physiological effect. Produced by the enhancement in his vital signs [9].
- Social effect. Activation and reinforcement of the communication both among patients and with carers [11].

Therefore, one can conclude that the main advantage that the ESTIMULO project brings in is the enhancement of well-being of senior people suffering dementia in their social context faced from different action points, such as the application of learning games, interaction with new technologies, mitigation of loneliness feelings, generation of protection instinct for a mascot, or psychomotor games.

Figure 2. Patient holding PARO

In a complementary way to the actions brought forth with the PARO tool, in the frame of the ESTIMULO project the typology of workshops and tests realized with patients according with their level of dementia are analyzed. As a fruit of this analysis, mobile applications are built allowing the health experts to compile all the information in digital form and analyze it in an efficient way. This analysis is based in the progression of each patient according to a defined series of competences. This way, it is possible to

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analyze whether a patient is showing a worsening of a given ability or, on the contrary, a noticeable improvement in a different ability or characteristic is taking place. This analysis will allow to build action strategies and totally personalized therapy workshops fitted to the state of the patient.

The ELDERTOY project

The first phase of the ELDERTOY project develops a therapy tool shaped as a toy targeted at elder people, with certain dependency degree, and to users of care centres. After that, this kind of solution is taken to other action field, the domestic one, having as its target senior people living at their own houses.

The toy has two main goals:

- Affective-recreational. Helping with the affective deficit that the elders may have in old people's homes.
- Therapeutic. To be a therapy tool, making compatible the recreational and therapeutic purposes.

The ELDERTOY platform acts in a personalized way, that is, it adapts its mood to the behaviour of the user, but also maintains constant its own personality, which represents a challenge in the games and workshops the users share.

In the design of the ELDERTOY platform it has been taken into account that the focus is with adult people, for which reason their general preferences have been taken into account, avoiding appearances that could raise rejection for its usage [12]. A key aspect is the animal appearance, which provokes a tendency to infantilize the toy (associating it with a cuddly toy) and to compare it with a real or toy animal, rising and adverse reaction. Hence, shapes have been considered with no association with actual living beings but with animated features producing empathy and stimulating the user to interact with ELDERTOY in an easy, natural and intuitive way [13].

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ELDERTOY has two different interaction channels that allow users to communicate with the device according to their preferences (gestures, voice, touch-screen interaction, external actuators adapted to different kinds of functional diversity, etc.). Also, it has elements allowing to show emotions, in such a way that an empathy bond with the user can be created.

Inner mobility has also been added to the ELDERTOY platform with the purpose to animate it, simulate internal life and enhance its attractiveness. Additionally, it has articulated elements simulating arms reinforcing the sympathy and affectivity of the device. The structure and design of these joints is flexible and robust. Thus the risks ensuing from moving or cutting elements are avoided, as well as the break-up risk of the said components due to falls and forced manipulation.

ELDERTOY usage is conceived both by means of inner manipulation, as also by projecting of multimedia content. By inner manipulation, therapy specialists are furnished with a tool able to run games by using the sensors integrated in the platform. In this way, it is possible to utilize the integrated touch-screen, an inertial sensor and gyroscope to determine device position and movement, voice commands, integrated web-cam acquired video, etc. Therefore, by direct ELDERTOY manipulation, talking with it and/or acting on its screen, it is possible to develop several therapy workshops on coordination, memory, concept-object relationship, calculus, language, etc.

Otherwise, ELDERTOY can be used as if it were a video game console. In this way, by multimedia content projection on a monitor, TV, or using a projector, it is possible to use any video, image, or interactive game of therapeutic inspiration which allow the user to develop his physical and cognitive abilities [14]. In this working mode, it has been considered very relevant the usage of a character as a kind of helper. This help will guide users, family and specialists (according to the selected game) in the steps that must be followed to play the game in the proper way.

The goal is that both direct ELDERTOY users as also their familiars get a customary user interface. In this way, if ELDERTOY is used outside institutions, for instance in the home environment, the graphic character is able on one part to indicate the elder person and his family the rules needed to accomplish a certain game, and on the other to advise the family about the conduct they must follow with the elder person with dementia to stimulate and reinforce him positively [15].

Scope of application

In a general way, it is possible to define three activity fields derived from the actions undertaken in ESTIMULO and in ELDERTOY. In each of these fields, tools and specific techniques have been applied to cognitive stimulation therapies.

- Virtual agent assisted therapy.
- Robot assisted therapy.
- Patient evolution management tools.

Virtual agent assisted therapy

It consists in the usage of virtual characters to make therapeutic rehabilitation activities, by using them as a stimulus and incentive [16]. In image 3 one can see the visual appearance of virtual character resembling a nurse.

Figure 3. Virtual agent.

The virtual character serves a guide the user can imitate and interact with. The ultimate goal of the virtual character is to serve as a help to health experts to conduct certain kind of tests, and also to familiars and the own patients in cases in which prescribed work must be continued in short term absences (for instance holidays, illnesses, etc.).

Virtual agent assisted therapy enhances personal competence and favours the consolidation and maintenance of knowledge, abilities and acquired habits, as also its application to day-to-day situations [17][18][19].

Regarding cognitive ability stimulation, a virtual agent correctly programmed can help the user to work on many areas specially including:

- Memory.
- Language.
- Thought.
- Calculus.
- Reminiscence.
- Object-meaning relationship.
- Music therapy.

In motor ability stimulation, there is collaboration with the therapist avoiding apathy and stillness. One gets high acceptability at any age, both by aged people as by children. The main aspects worked on are:

- Movement repetition.
- Coordination.
- Equilibrium.
- Object drawing ability.
- Space.
- Rythm.
- Body concept.

Many elder people living in old people’s homes often enjoy holidays at the houses of their families. After these stances, and having left aside the routine, not making the daily exercises, when they return, they show a greater cognitive worsening than before.

The avatar resolves partly this problem, because it allows the patient to make home exercises he is already familiarized with. It also serves as a help for the family in the adequate treatment of the patient, something not easy in many cases. Thus, it makes a complementary function as family educator, indicating the most adequate conduit to face the behaviours and reactions of the person with dementia.

The usage of this kind of virtual agents, as also of the associated multimedia content, works when ELDERTOY is used in game console mode, or alternatively, by means of a web browser accessing a given platform in which the games and the workshops for a given patient (in the ESTIMULO case) are personalized.

Robot assisted therapy

It consist in the implementation of new gerontology therapies including the usage of robots endowed with motion and communication abilities [20][21].

The usage of robots connected with the user helps their relaxation and enhances communication among patients, and of these with their families and therapists.

Both the PARO robot platform, used in the ESTIMULO project, as well as the ELDERTOY platform, seek the affinity with users suffering dementia and with the people in their environment, being attractive at all ages, fostering intergenerational relationship.

They allow to work both in the strengthening of bonds as well as the carrying out of workshops.

The main bonds to reinforce are:

- Affective.
- Emotional.
- Happiness feeling.
- Relaxation.
- Motivation.
- Commitment.
- Responsibility.
- Self esteem.

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In order to get good results and reinforce both cognitive abilities as also the bonds mentioned, the following workshops are realized:

- Memory.
- Language alteration.
- Object recognition.
- People recognition.
- Planning.
- Organization.
- Motor abilities.

Patient evolution management tools

In patient monitoring it is fundamental to have a proper record of the therapy indications received and his evolution along therapy sessions. To that end, several techniques are employed for storage and data analysis that facilitate the health professionals the control of the information generated.

These tools are a warrant of success and of future in the field of applied robotics in healthcare. Is needed to show the progression of patients to extend these good practices and achieve that the community can take advantage of its benefits.

Once all the data obtained through the realization of tests have been analyzed, the system integrated in the ESTIMULO project is able to evaluate the competences and abilities of each patient depending on a series of basic rules provided by the health experts. In this way, the timely progression of the cognitive abilities can be checked, grave conditions are detected and a personalized therapy is planned aiming at the mitigation of the cognitive worsening detected.

Technology tools

Here we deal with the technical and functional characteristics of the ICT tools deployed in the ESTIMULO and ELDERTOY projects. Concretely, we attend to the ELVIRA solution, consisting in a virtual conversational agent, the PARO robot, and the ELDERTOY device.

ELVIRA

ELVIRA (the virtual agent) is a last generation user interface combining computer graphics techniques for the presentation of a virtual assistant and computer vision techniques for face recognition, eye contact simulation, with voice and gesture interaction. In those cases where verbal and gesture communication isn't efficient enough due to the involved complexity, the virtual agent interface is accompanied by an accessible interface, allowing a direct interaction with the contents in an easy and intuitive way.

Avatar modelling and the affective model are the means to enhance the closeness perceived by the system user. The model is personalized depending on the way the user works with the system, with the objective of giving him a treatment continuously adapted to the user profile. In turn, the affective model seeks to mitigate the mechanistic feeling of the interaction enriching it with expressive facial gestures complementary of the dialog.

Such agents are a response to the challenge generated by the increasing complexity of digital services offered to citizens, so they can break the actual digital divide. The guiding principle in these systems is that the closer the interaction with a machine is to human attention, the greater its usefulness, thus diminishing entry barriers for users who are not technologists or need further assistance.

The virtual agent ELVIRA handles a wide range of technologies including voice dialogue, artificial affectivity and domain decoupled problem solving, supported by Cognitive Computing techniques by means of a reasoning engine based on emerging semantic standards. This allows an increase in the

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maintainability of the affective models, of dialog management, personalization, and domain pragmatics.

As a support for interaction, Affective Computing research results such as formal models of Appraisal Theory coming from the cognitive psychology have been used [22][23]. In the dialog area, Computational Linguistics results on syntactic and semantic analysis allow to relate logic forms to plain text [24]. As for dialog management, phenomena such as interruptions or context management have guided goals more ambitious compared to actual automatic vocal systems [25].

The interaction is multimodal, bidirectional audiovisual, offering virtual reality, speech synthesis and context-dependent speech recognition, in addition to using artificial vision techniques. These techniques allow the recognition of users, both facially and by voice footprint, enhancing the feeling of familiarity of the user.

User history with the system, previously registered, allows to choose how to make the treatment more efficient and provide a personal touch such as greeting by name, remembering preferences, or adapt to specific needs.

Similarly, the application of machine learning techniques allows the detection of emotion from voice and facial appearance or the detection of a repertoire of gestures.

In parallel, user rapport is achieved by means of a convincing reactive behavior on behalf of the virtual agent. The realization of this behavior is done by template-based phrase generation or using syntactic synthesis [26]. Regarding non-verbal behavior, this includes the adoption of facial expression, and the performance of gestures and scene movements. This channel is necessary in emotion synthesis. In this tasks real-time computer graphics techniques with shape blending and character animations are employed. The creation and manipulation of computer graphics content is made through a hub of computer graphics software based on a common standard for asset exchange, for tasks such as modeling, lightning or animation.

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PARO Robotic Platform

PARO (Personal Assistant RObot) is a japanese robot designed with the aspect of a baby seal. It has several sensors distributed in its body to react to people contact. It has also memory that allows it to react to its name when uttered. It makes gests, opens and shuts its eyes, and emits sounds resembling a real seal. It has been developed during the last 15 years by the Japanese National Institute of Advanced Industrial Science and Technology and it has been awarded with numerous international prizes.

Since 2008, the Danish Technological Institute works on applications of the robot seal as a therapeutic tool, above all in aged people with brain deterioration. Its psychological benefits have already been checked (it reduces stress level), the social benefits (enhances patient communication), and physiological (diminishes blood pressure, heart rate and muscular stiffness).

In advanced stages of dementia, through touch and caresses, motor function is stimulated, as also is the coming out of the state of self absorption.

PARO fosters the development of experiments stimulating certain cognitive abilities of the patients, mainly focused on touch sensations, sight contact, sound activity, etc. In a percentage near 75%, PARO has adopted a mediating role, establishing a bond between the carer and the patient, in a way that does not irritate or make the patients uneasy, but also promoting their mutual communication.

ELDERTOY development platform

The ELDERTOY development platform consists in a robot-toy with a friendly appearance, including mainly a touch screen, a gyroscope, an accelerometer, USB and HDMI connectors, webcam, microphone, speaker and touch sensors.

ELDERTOY allows user interaction through several channels (touch screen, voice, gesture, etc.). The screen is the support for games and for the addition of expressivity to the final design of the toy. The gyroscope allows to get the orientation of the toy so it can take part on the games. Connectors make possible to use the toy for video games, or the expansion by complementary devices (joysticks, external actuators, etc.). The camera, microphone and speaker aim that the user identifies himself with the toy, endowing it with expression. By means of these devices the ELDERTOY platform gets its contents displayed in a multimodal way, is able to recognize voice, and to detect the presence of people around it.

The ultimate goal is that patients get relaxed by interacting with ELDERTOY, begin to spontaneously chat with each other, families and health staff, and that in the companion of the ELDERTOY platform they get involved in several activities that wouldn't be realized without external stimuli. These activities have a therapeutic intention forcing mind stimulation and exercising resulting in a mitigation of different cognitive impairments that may occur at a certain age.

In short, it seeks to improve relationships between patients, improve cognitive responses and to get them to reduce anxiety states, depression and loneliness that may be present.

Conclusions and further work

The ESTIMULO and ELDERTOY projects are being developed in the actual context of ageing population and new research using social robotics to enhance life quality in elder people.

The ESTIMULO project achieves the results of animal therapy using the PARO robot mascot, avoiding the counterproductive effects of the former, and allows also the extraction of patient data evolution. The activities developed in the ESTIMULO project concern in picking patient state data by means of tests conducted before, during and after the workshops using with the robot. As a future work, the data collected on a population of 24 elder people with a varying grade of dementia will be evaluated. The goal of this evaluation is to determine the effect of the workshop including the seal-robot, analyzing the progress or regression on differing personal competences in comparison with the expected natural process. The ELDERTOY project develops a therapy toy for elder people having a playful and therapeutic purpose. This project encompasses everything from the physical construction of the toy to the software development necessary to cover both the playful-affective and the therapeutic aspects.

We establish as future work for the ELDERTOY project the testing of the progress of the users regarding coordination, memory, object-concept relationship, calculus and language, after the usage of the robot-toy.

Both projects act in three fields: virtual agent assisted therapy, robot assisted therapy, and patient evolution management tools. To that end, three technology tools are used: Elvira, as a virtual conversational agent, the PARO robot, and the ELDERTOY device.

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