Evaluation of Natural Technological Interfaces for Children with Psychomotor Disabilities

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Abstract— **Within population with disabilities, there is a group that has intellectual, sensory, motor disabilities, or a combination of them. The International Classification of Functioning, Disability and Health (ICF) defines disability as an umbrella term for impairments, activity limitations and participation restrictions. It is estimated that over 15 % of the world's population is afflicted by disability in some form. In Argentina this prevalence reaches 7.1%. When these people want to use any technological device, usually find that its physical interfaces are not accessible. Often they need adaptations, raising costs but accessibility is not totally guaranteed. Current technologies allow "more natural" interfaces, where the feedback is immediate. The application of appropriate technology with natural or intuitive interfaces, allow greater accessibility than adaptations commonly used for the overall development of students with psychomotor disorders. The objective of this work is to facilitate the comprehensive development of students with senso psychomotor disorders attending the Special School Beatriz Martinez A. Allio, through the incorporation and implementation of natural interfaces for working with computers in education, offering teaching a complementary tool for the development of their daily activities. The interfaces of hardware and software implementation are proposed to achieve the overall goal. It is intended to make at least a touch screen and at least one interface with the Kinect camera game console Xbox 360.**

Keywords— **Natural Interfaces, Human-Machine Interface, Disability.**

I. INTRODUCTION

It is estimated that over 15% of the world's population is afflicted by disability in some way [1] while in Argentina this prevalence rises to 7.1% [2]. The International Classification of Functioning, Disability and Health (ICF) defines disability as an umbrella term for im-pairments, activity limitations and participation restrictions [3].

When people with disabilities want to use any technological device (such as a personal computer), they usually find interfaces that are not designed for them. Often they have to look forward for some kind of motor, visual or software adaptation for increasing access [4]. However this not always reach good results. Additionally, these interfaces require an abstraction level (and time-space adaptation) that is not always present in the user. For example, something as simple as using a mouse to access a computer: the user has to move his mouse in a horizontal plane to move a virtual cursor on a screen located in a vertical plane, which for some of these users is very complex to assimilate and interpret.

Current technologies allow "more natural" or intuitive interfaces, where there is a direct relationship between the user and the object to interact. For example, touchscreens (where the user "touches what he sees" as target) or gestures interpretation such as the Kinect camera, where there is not a physical interface between the user and the device.

This project is part of the "Beatriz Angélica Martinez Allio" Special School located in the city of Cordoba, attending about 140 students with psychomotor and intellectual disabilities associated. This institution is a provincial public school.

These children and teenagers are in a situation of high economic and cultural vulnerability, positioning them on a map of a deep social inequality adding their disability status and getting with this a worst exclusion.

II. AIMS AND OBJECTIVES

The project hypothesis was: *The application of appropriate technology with natural interfaces allows greater accessibility than commonly used adaptations for comprehensive development of students with psychomotor disabilities*.

The aim of this project is to facilitate the comprehensive development of students with sensory-psycho-motor disorders attending the school, through incorporation and implementation of natural interfaces for working with computers in education, offering a complementary tool for teachers' development of their daily activities.

The objective of this project is to implement hardware and software interfaces to achieve the overall aim. It is intended to make at least a touchscreen and at least an interface with the camera game console Xbox 360 Kinect.

III. THEORETICAL FRAMEWORK

A. Natural User Interfaces

In the book "Brave Nui World: Designing Natural User Interfaces for Touch and Gesture" [5], touch and gestural interaction is discussed as a way that allows the construction of a Natural User Interface (NUI) [6]. However, we believe that a NUI can be created with other ways of input as well. In fact, it could be imagined following design guidelines we set to create a new type of interface for mouse and keyboard, voice commands, gestures in the air, mobile phones, and so on. Input and output technologies offer us the opportunity to create a more natural user interface, although they do not themselves nor defined or guaranteed.

IV. Materials and Methods

A. Tecnhologies used

Six technologies were selected with the criterion that users initially feel intuitive as their previous experiences [7] [8] [9]:

01-Touchpad; 02-Mouse; 03-Kinect [10]; 04-All In One (with touchscreen); 05-Leap Motion [11]; 06-Tablet (Android) 10 inches.

B. Methodology

1) Subjects - students selection

Tests were conducted on 12 school students mostly with cerebral palsy sequelae [12]. The subject selection criterion was given by the following items:

Grade (in school); Shift (Morning-Evening); Motor Impairment; Expressive Language Impairment; Cognitive Impairment (Comprehension); Cognitive Impairment (Attention). See Table 1.

Table 1 Selected students characteristics

Student	Inning (Morn-Evening	School Grade	Motor Imp	Lang Expr Imp	Cogn (compr) Imp	Cogn (attn) Imp
01-CM	E	1°	YES	YES	YES	YES
02–CC	M	5º	YES	YES	YES	YES
03–DE	E	4º B	YES	YES	YES	YES
04–FD	M	6º	YES	YES	YES	-
05–JJ	M	1º YEAR B	YES	YES	NO	NO
06–JS	E	1º	YES	YES	YES	YES
07–JG	E	3º	YES	YES	YES	NO
08–JC	E	4º B	YES	YES	YES	YES
09–LDS	E	3º	YES	YES	YES	YES
10–NV	E	4º A	YES	YES	YES	NO
11–PS	E	2°	YES	YES	YES	NO
12-SS	E	2º	YES	YES	YES	YES

Additionally, we worked with the profiles of the selected students in order to determine the selection was properly performed.

All of the subjects were authorized by their legal tutors and the school's ethics committee.

2) Activity Log

In testing students were recorded by an audiovisual recording (filming). They used technologies as an interface for a target: to make a click on a specific place on the screen. Each test consisted of a task where students had to "hang an apple on a tree", with different technologies, on an image like this:

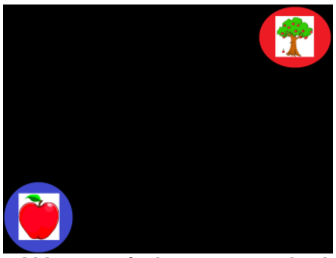

Fig. 1 Screen used like a test, for hanging an apple (down left corner) on the tree (upper right corner)

Thus, subjects had to click on the apple and then click on the tree to meet the instructions.

C. Data Analysis

To perform the analysis, Table 2 was built:

Table 2 Relationship students-technologies to analyze

	01 Touchpad	02 Mouse	03 Kinect	04 AIO	05 Leap Motion	06 Tablet
Stdnt01						
…						
Stdnt12						

Two types of analyzes were performed:

- A Transversal Analysis per Technology (vertical) compares the performance of all students with the same technology.
- A Longitudinal Analysis per Student (horizontal) compares the performance of each student with different technologies.

Transversal Analysis per Technology

Videos of students performing clear instructions with the different technologies were analyzed. Five observers, professional members and contributors to this project, with similar criteria were taken to perform the evaluation.

Following the aim of this project, it was taken into account that each technology generates a user interface that can determine how "natural" is its use. That's why for analysis the following features were chosen to evaluate:

Chance to Generate Fatigue (GF); Chance of Generate Distraction (GD); Ease of Use (FU); Flexibility to the user (FB); Required accuracy of the user (PN)

Each observer gave values to the features from 4 to 0 for quantitative assessments *Nothing-Fair-Good-Very Good-Excellent* in the first two features while the values used in the last three features were 0 to 4 corresponding to qualitative assessments: *Nothing-Fair-Good-Very Good-Excellent*, as shown Table 3 (partially shown because of lack of space).

Evaluation criterion was chosen so that the observers introduce the least variability in data analysis, and thus achieve greater confidence in the statistical analysis. Thus an arrangement is performed in Tables 3 and 4 as an example for the Student 1 as feature GF, and the values for T1 ... T6 Technologies, with a total of 25 tables as follows.

Table 3 Analysis per Technology Log

Observador: XX											
Completar arriba con el nombre del observador											
Completar con X la opción visualizada											
	Genera fatiga?					Genera distracción?					Faci
	N	R	B	MB	E	N	R	B	MB	E	N
Alumno 01	4					4					
Alumno 02	4					4					
Alumno 03		3				4					

Table 4 Analysis per Technology

GF						
Observer	T1	T2	T3	T4	T5	T6
1	1	0	2	0	0	0
2	1	1	2	0	2	1
3	1	1	1	0	0	0
4	2	0	2	2	2	0
5	0	1	1	0	0	0

After the evaluation by five observers a sample of five students (n = 5) was randomly took and conclusions about the behavior of the technologies involved and what kind of user interface generate were searched.

For analysis of these data the nonparametric Friedman test was used. This technique allows to evaluate comparison of variances if among technologies (treatments) become evident statistically significant differences.

Longitudinal Analysis per Student

Log data from the longitudinal analysis consisted in testing each student with each technology. There were 5 observers, completing the following form:

After performing all tests, the sum of all records of the 5 observers was performed.

The next step was to calculate the probability for each sum, considering the number of observers.

Because the information was recorded on a qualitative scale, it was quantified by a weighting of 0-4.

This weighting was in ascending or descending order, depending on the feature to record and what is desirable as an ideal interface.

The next step was to make the product of probability and weighting, yielding the weighted probability of each feature. Each weighted probability of each feature was added, giving a value that took into account the sum of all observers for that feature, but according to the weighting. Subsequently all features were added, giving a total valuation (called Points) per pupil, per technology as shown in Table 5.

Table 5 Form for Longitudinal Analysis

Observador:					
Completar arriba con el nombre del observador					
Completar con X la opción visualizada					
	Nada	Poco	Medio	Bastante	Muchisimo
	No alcanzó	Regular	Bueno	Muy bueno	Excelente
Facilidad motriz de uso					
Intepretación de la consigna					
Cumplimiento de objetivo (consigna)					
Distracción durante el proceso					
Presencia (cantidad) de intentos fallidos					
Necesitó asistencia					
Interpretación de uso del dispositivo					
Observaciones:					

Finally, the sum of the ratings for all technologies performed by each student was made.

Thus, it arrived in a summary per student as stated below as an example in Table 6.

Table 6 Summary Student02 - Longitudinal Analysis

ALUMNO 02	CC			
Puntaje	*Tecnología*		*mayor*	*menor*
25.8	01-Touchpad		27.4	22.4
26	02-Mouse		04-AIO	03-Kinect
22.4	03-Kinect		Diferencia	5
27.4	04-AIO		Suma Total	150.4
24.6	05-Leap Motion			
24.2	06-Tablet			

After this longitudinal analysis (quantitative), a contrast to the profiles of each student (qualitative) was performed and thus reaches more comprehensive conclusions.

V. Conclusions from the analysis

A. Conclusions from Transversal Analysis

Most natural technologies were Tablet (T6), AIO (T4) and mouse (T2) respectively. This may indicate that touch interface technologies are “more natural” than the rest. This group recognizes the Mouse -no touch technology- but has a similar behavior, which can be the result of prior knowledge of users.

The “less natural” technologies were Leap Motion (T5), Kinect (T3) and Touchpad (T1).

B. Conclusions relating Longitudinal Analysis and Student Profiles

- The touchscreen technologies that students are not aware obtained the highest score and recurrence.
- There were students who scored high marks in 01-Touchpad and 02-Mouse from previous experience. This is because these technologies are more widely used standard technologies and they were more familiar with its use
- The most commonly used technologies with lower scores are:
  1) 02-Mouse with recurrence 3 of 12 students
  2) 05-Leap Motion with recurrence 4 of 12 students, although with higher scores than 02-Mouse
  3) 03-Kinect with recurrence 3 of 12 students has a better score than the previous
  - From the above it might initially conclude that these technologies are not very intuitive or natural, or require long attention span, visual-spatial coordination, accuracy and/or abstraction from users (hence the lower score). This has a different explanation in the case of 02-Mouse where this technology scored higher score because users were more familiar with its use

VI. Future researches and projects

During the development of this project, a need for building and implementing a multisensory room was identified. Following this, a new research project on the call “SeCyT 2014-2015” that has continuity with the current was raised. It was presented and approved under the title "Application of Natural Interfaces in Multisensory Rooms".

This project hypothesizes that while the current multisensory rooms have some degree of effectiveness, they don’t apply many advanced technologies, with all the advantages and applications they represent and the flexibility of being programmable. Current technologies allow more natural interfaces, where there is a direct relationship between the user and the object to interact.

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References and Bibliography

1. http://www.who.int/mediacentre/factsheets/fs352/es/index.html
2. http://www.indec.gov.ar “Datos de la Encuesta Nacional de Personas con Discapacidad 2002-2003”.
3. World Health Organization (2001). Clasificación Internacional del Funcionamiento, de la Discapacidad y de la Salud (CIF)
4. “El papel de las interfaces en la generación y transmisión de conocimientos dentro de una organización” http://portal.educ.ar/debates/sociedad/sociedad-conocimiento/el-papel-de-las-interfaces-en-la-generacion-y-transmision-de-conocimientos-dentro-de-una-organizacion.php (last view february 2014)
5. Wigdor Daniel, Wixon Dennis (2011). Brave Nui World: Designing Natural User Interfaces for Touch and Gesture. Ed. Morgan Kaufmann.
6. “Natural User Interface (NUI) Group” http://nuigroup.com/go/lite (last view february 2014)
7. Sánchez Montoya Rafael, “Ordenador y discapacidad: Guía práctica de apoyo a las personas con necesidades educativas especiales”. Editorial CEPE, S.L. c/ General Pardiñas, 95. 28009 MADRID (ESPAÑA)
8. Sánchez Narvaez, José. “Manual de referencia sobre tecnologías apropiadas”. 2008. © Instituto de Transferencia de Tecnologías Apropiadas para Sectores Marginales -José Sánchez Narvaez-ISBN: 9972-621-02-X
9. Scherer Marcia J. “Assistive Technology Matching Device and Consumer for Succesful Rehabilitation”. American Psychological Association, 2003.
10. “Kinect for Windows” http://www.microsoft.com/en-us/kinectforwindows/ (last view february 2014)
11. https://www.leapmotion.com/
12. “Parálisis cerebral: Esperanza en la investigación” http://espanol.ninds.nih.gov/trastornos/paralisiscerebral.htm (last view february 2014)