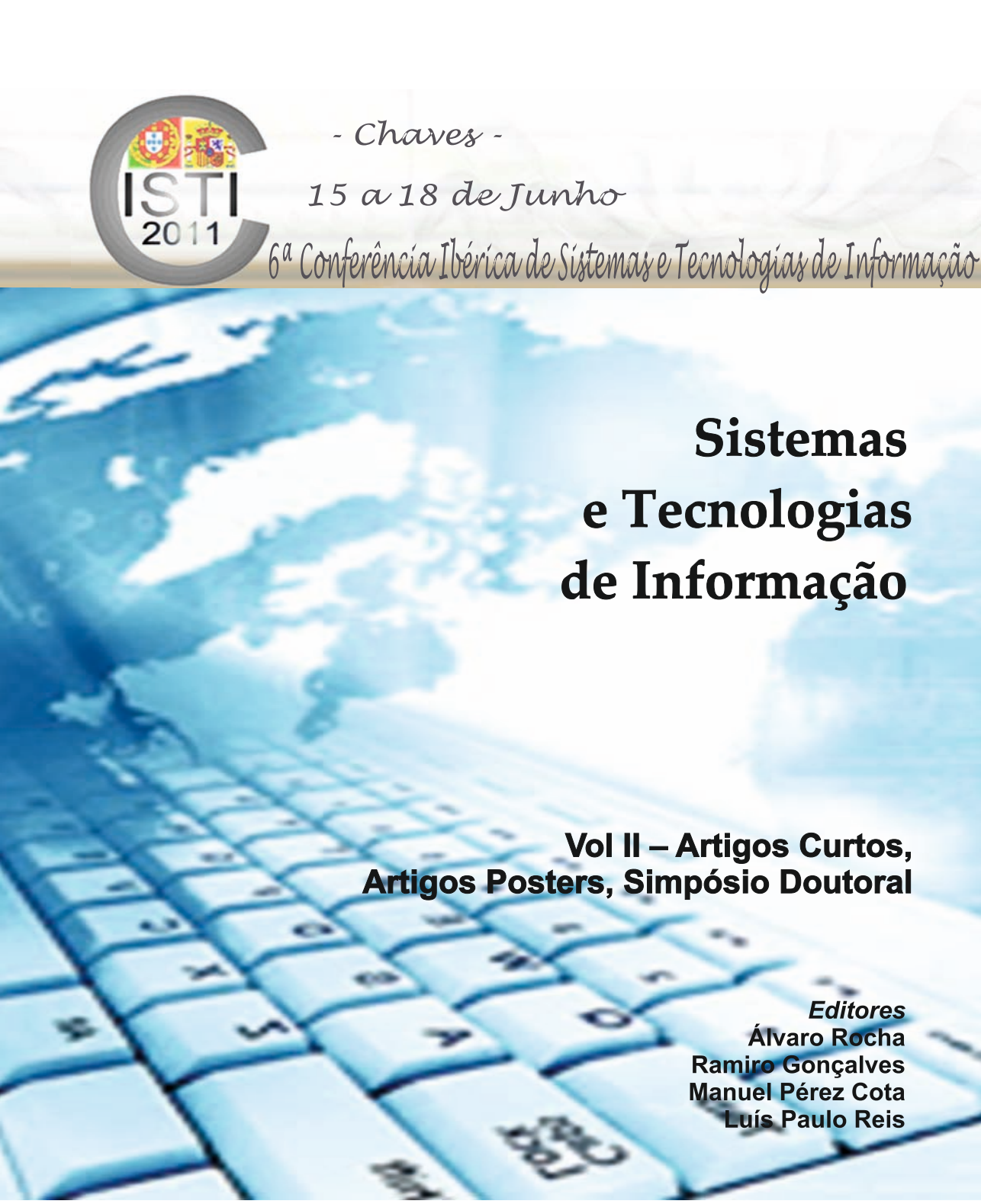

- Chaves -

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Vol II – Artigos Curtos, Artigos Posters, Simpósio Doutoral

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Natural User Interfaces in Serious Games for Rehabilitation

A Prototype and Playability Study

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Abstract— **This paper addresses research development regarding the adoption of natural user interfaces (NUI) in the Serious Games for Rehabilitation area of application. From previous studies, we identified as a research opportunity the potential benefits of the adoption of more natural interaction modalities. This paper describes the main problems and how serious games and NUI can benefit the process of rehabilitation. We describe our recent work on this subject, including the design of a game prototype using alternative (in respect to the conventional WIMP) interaction. We conducted a playability study in order to make it possible to evaluate and measure the benefits of the newer forms of interaction. From the results study, we concluded that the introduction of the natural interaction modalities has increased the attractiveness and intuitiveness of the prototyped Serious Game. Lastly, we report some conclusions and identify research opportunities and open problems in this area.**

Keywords - Serious Games; Rehabilitation; Natural User Interfaces

I. INTRODUCTION

Serious games are becoming more and more popular and, although all authors agree that entertainment in these applications is not the primary goal, there is no current single definition of the concept. They have been applied in many diverse areas [1-3]. A domain area where serious games are assuming a relevant role is the rehabilitation area.

Traditional treatment approaches include exercises often considered repetitive and boring for patients. The use of computer games to augment physical and cognitive rehabilitation can offer the potential for a significant therapeutic benefit. Games require cognitive and motor activity so they can engage a person's attention [4]; they offer increasingly difficult levels that give the player the sense of challenge in his progress and in a way that is also adapted to his skills; and they distract the patient's attention and as such they can be used to aid in the management of pain [5]. There have been reported in the literature several works that identify relevant game characteristics in the rehabilitation domain of application [2]. In a previous work [6] we identified relevant criteria for the classification of Serious games in rehabilitation area and we identified interaction technology as a relevant criterion to achieve a more motivational purpose in rehabilitation therapy using computer games. We want to study if the use of more natural forms of interaction can augment the motivation in the rehabilitation sessions by measuring and evaluating the benefits of its introduction in rehabilitation serious games. We believe that the use of more natural user interfaces can benefit the process of rehabilitation since the patients have several cognitive and motor disabilities which difficult the way they interact with the system.

The rest of the paper is structured as follows. Section II presents the concept of natural user interfaces, its importance in rehabilitation serious games and a summary of more relevant works of Serious Games for Rehabilitation found in the literature using natural forms of interaction. In Section III we describe the implemented game prototype. In section IV the usability test done is described, along with the results obtained. Finally, in Section V, major conclusions are drawn and directions for future work are suggested.

II. MORE NATURAL FORMS OF INTERACTION

Advances in the development of computer vision, speech and audio processing, along with development in hardware like inexpensive cameras and sensors has led to a growth in the research on a human computer interaction more natural and intuitive. A natural user interface is the system by which users interact with the computer, composed by input devices other than the traditional keyboard or mouse devices.

These devices give the user the sense of an easier and intuitive interaction with the system and make him to learn more rapidly how to control the computer application. In a multimodal interface, we can have more than one modality (e.g., speech, gesture, writing, and others) and the system accepts many different inputs that are combined in a multiple way, increasing the user degrees of freedom. In terms of input devices we can have modalities that are equivalent to human senses such as: cameras (sight), haptic sensors (touch), microphones (hearing). However, other input devices such as: keyboard, mouse, motion input and writing tablet, do not map directly to human senses. The visual modality, for instance,

TABLE I. REVIEW OF REHABILITATION SERIOUS GAMES USING NATURAL FORMS OF INTERACTION

	Sensors/Actuators				Detection Type					Social dimension	Evaluation Test
	Force feedback	Accelerometer	Infrared sensor	Webcam	Image detection	Motion detection	Sound detection	Gestures detection	Facial Detection	Competitive/ Collaborative	Sample size
Betker et al. [7]	X					X				None	3
Ma et Bechkoum [8]						X				None	8
Conconi et al. [9]						X				None	--
Cameirão et al. [10]						X				None	6
Battochi et al. [11]								X		Collaborative	4
Burke et al. [5]				X				X		None	3
Vanaken et al. [12]	X	X	X			X				Collaborative	--
Ryan et al. [13]		X				X				None	--
Brown et al. [14]			X			X				None	--
Alankus et al. [15]		X	X	X	X					Competitive Collaborative	4
Burke et al. [16]				X				X		None	--
Saposnik et al. [17]		X	X			X				None	22

includes any form of interaction that can be interpreted visually, and the audio modality any form that is audible [18].

The application of Virtual Reality (VR) technology for the rehabilitation of cognitive and motor deficits has been growing in the last decade and stroke patients have been one of the main target populations for these new rehabilitation methods [5]. These VR based-methods can offer the patients to be part of immersive experiences that are engaging and rewarding for them. Several motion tracking devices have been introduced by the gaming industry, using the game consoles for home-based rehabilitation, like the Nintendo wii with the wiimote, PlayStation 2 EyeToy, PlayStation 3 Eye and Microsoft Kinnect and PlayStation 3 Move systems.

Table 1 summarizes the more relevant works found in the literature of serious games for rehabilitation using natural forms of interaction. The "--" means that this feature is not mentioned in the paper reviewed.

III. A SERIOUS GAME PROTOTYPE FOR REHABILITATION

To study if the use of more natural forms of interaction and serious games can augment the efficacy of the rehabilitation process, by increasing the motivation of the patients in the therapy sessions, we choose one of the games from the system RehaCom, to design and implement and introduce to it new forms of interaction. RehaCom is composed of a set of serious games modules (for executive function, memory and attention training, among others) and was found to be a reference system in rehabilitation serious games, for cognitive rehabilitation [19]. "Memory for Words" was the game chosen from RehaCom system, included in the "Memory Training" category of RehaCom modules. The game goal is to recognize a set of words that were memorized in a first (learning) phase and that after appear in a sequence of other words. In RehaCom "Memory for Words" game the words were chosen by the user using the special panel, the mouse or a touch screen. Our implementation of the game considers three forms of input: using the mouse (mouse detection), using some noise (sound detection), or using some motion (motion detection). Fig. 1 a) shows the screen interface of our game that is presented to the player asking him to choose from one of these forms of interaction. Fig. 1 b) and c) presents some screenshots of the game play. The hardware required to run this game prototype consists in a laptop or computer desktop with internet access, a microphone and a webcam.

The prototype was implemented in the Adobe Flash platform, using the ActionScript 3.0 programming language. With the sound and/or motion interaction, one of the problems is that game velocity is limited by the detection process itself, and a user cannot play the game as quickly as it would if he was using only mouse clicks. In the sound input option of our game, the detection of a player's action is achieved by checking when the activity level reaches a certain threshold. The approach in our motion input option game consisted in sampling a sequence of activity levels and use these and a threshold value to decide if an option/word was selected.

IV. USER TESTING

To validate our prototype we conduct a small usability study with 20 healthy users to evaluate the playability of the game in what concerns the three input forms of interaction, before running a usability study with patients in rehabilitation. First we made a small demonstration of the three input options of the game. Each user then played five times the game in each of its three input options and filled a usability questionnaire. The first two times were for him to become accustomed to the interface and the remaining to evaluate the game. Fig. 2 presents an excerpt of the questionnaire we used.

Most of the participants enjoyed playing all the input options, with the sound input option being the most enjoyable and the motion option being considered the least enjoyable. The sound input option was considered the easier to play and

Fig. 1 – Screenshots of our words memory prototyped game (a) Screen interface; (b) and (c) Screenshots of our game play

1) **Evaluate the "Memory for Words" game in each input form in respect to the following (choose only one option):**

1. Strongly disagree **2.** Disagree **3.** Neither agree nor disagree 4. Agree **5.** Strongly agree.

	1	2	3	4	5
1. The game is enjoyable.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
2. The game is easy to play.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
3. The game is challenging.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
4. I would play it again more times.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
5. The feedback is effective.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
6. The input mechanism is intuitive.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
7. The game interface is consistent.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
8. The game interface is clear.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
9. The game colours are appropriate.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐
10. The speed of the game is too fast.					
Mouse Detection	☐	☐	☐	☐	☐
Sound Detection	☐	☐	☐	☐	☐
Motion Detection	☐	☐	☐	☐	☐

Fig. 2 – An excerpt of the questionnaire used in the usability study.

the mouse input option the less easy to play. Despite this, the mouse input option was considered the most intuitive and the motion input option the less intuitive. Still, about 40% of the participants didn´t find the game challenging, although about 30-35% found the contrary.

The majority of players considered play again more times the game, with the sound input option being the most chosen and the mouse input option being the less chosen to play again. In what concerns feedback, the sound option was found the most effective and the mouse option the less effective.

The majority of participants also found the input mechanism of the game intuitive, with the mouse option being the most chosen and the motion option the less chosen. Most of the participants found the game interface consistent and clear. In respect to game colors, only about 35% of participants found it too appropriate (15% disagreeing). In what concerns the speed, the majority of the participants considered it appropriate.

When asked to compare the three input game options, the participants felt more involved with the motion input option, considered the mouse option the most intuitive input and would play again the motion and mouse option.

Fig. 3 presents a chart illustrating the results obtained in each input option in respect to question 1 of the questionnaire.

V. Conclusions and Future Work

To study the effect of the introduction of new forms of interaction in rehabilitation serious games it was developed and tested a serious game prototype with healthy users that can be played in three different versions which differ in the interaction input form: mouse, sound or motion.

Some design problems were identified in the study that can be improved in future versions of the game, such as the use of more appropriate colors in the screens and the introduction of more instructive text messages and sounds. Also in the sound and motion option of the game, would be desirable the introduction of a more reliable facility to make a proper calibration of the input sensors and recognition procedures, increasing the overall robustness of the system, in varying noise and illumination conditions, and also adapted to the patient intrinsic motion and voice characteristics, for instance. Some participants in the evaluation reported they did not like much the motion input option, or considered it less intuitive, simply because they didn´t know how much they have to move in front of the camera to make the words selections. In many situations, a similar problem occurred for the sound option. However, despite of that, the sound and motion input option of the game provided the most involvement of the users in the game and were the options the users showed more interest to play again. As an immediate direction for future work is the improvement of the above mentioned features.

The prototyped game can be played online, making it more accessible to all users, including to patients in rehabilitation, and providing a low cost solution to patients training and easing a home rehabilitation, in addition to traditional therapy. The input mechanism is more intuitive and can more easily be adopted by people with disabilities and impairments in

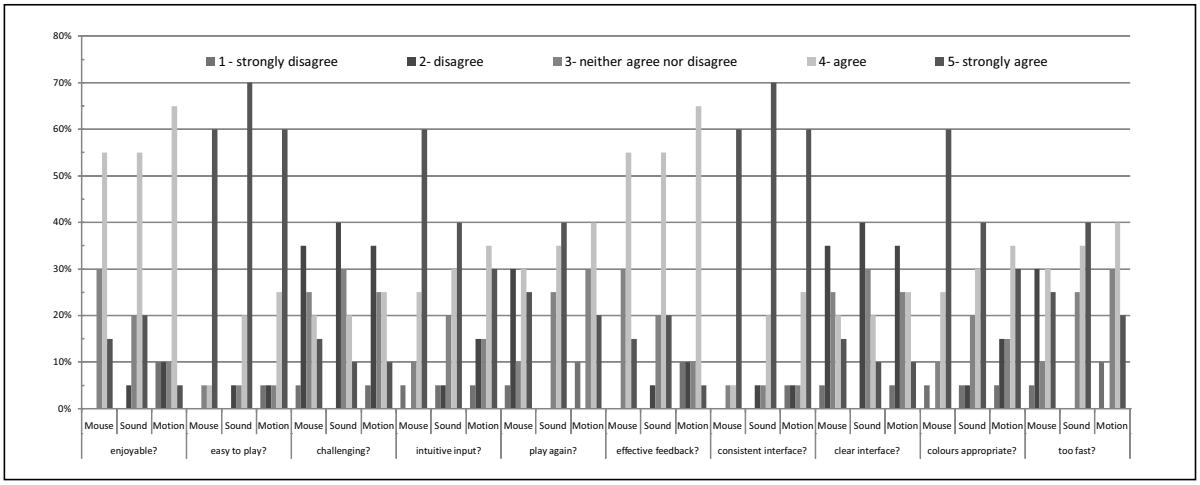

Fig. 3 – Results from the questionnaire relatively to question 1.

rehabilitation. As future work we plan to introduce a facility of saving user profiles (for progress monitoring) and to apply these new forms of input to other games of RehaCom. Later we plan to conduct a more comprehensive study involving a larger sample with patients in rehabilitation. In this way, more research is still needed in order to demonstrate how distinct and natural input modalities, such as body motion, hand gestures, voice recognition, and facial expressions can increase effectiveness of serious games for rehabilitation.

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