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SERIOUS GAMES AND REHABILITATION FOR ELDERLY ADULTS

Hugo Barbosa
Faculty of Engineering
University of Porto
Porto, Portugal
pro11027@fe.up.pt

António V. Castro
Engineering School
Polytechnic of Porto
Porto, Portugal
avc@isep.ipp.pt

Eurico Carrapatoso
Faculty of Engineering
University of Porto
Porto, Portugal
emc@fe.up.pt

Abstract –

Healthcare is continually being improved, especially regarding the use of the current technologies. In the field of rehabilitation, the use of serious games and related technologies may help to develop new rehabilitation procedures. There are several approaches in the area of rehabilitation that invoke technology for a more comprehensive and dynamic learning process aimed at the physical and psychological recovery of persons with a disability or limitations, with a view to their possible recovery and reintegration. This contribution presents research on systems for rehabilitation, focusing on the elderly, based on exercises and serious games. It provides an overview of the state of the art, in order to support and guide future work in this area.

Keywords –

Serious games; rehabilitation; multidisciplinary approach; support technology; collaborative platform

I. INTRODUCTION

The proximity of the technologies with rehabilitation has been accentuated in recent times as a result of technological developments, which led to the evolution of a traditional approach based almost exclusively on a connection between therapist and patient for systems that resort to technologies that take on a supporting role to therapy. An assistive technology device can be defined as "any item, piece of equipment, or product, whether it is acquired commercially, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities" [1]. It enables them to have a better quality of life as well as assists in various tasks. In the construction of assistive technologies in the rehabilitation process it is not only necessary to know the physical principles that govern their designs, but also to adhere to some key principles that govern the applications of technologies for people with disabilities. To be successful, the needs, preferences, abilities, limitations, and even environment of the individual seeking the assistive technology must be carefully considered. There are at least some considerations that exist in the field of assistive technology: Although assistive devices can make accomplishing tasks easier, technology alone cannot mitigate all the difficulties that accompany a disability. Assistive technologies must be individualized because similarly disabled persons can have very different needs, wants, and preferences. Assistive technologies are sometimes complicated and expensive. Sometimes low technology

devices are the most appropriate and even preferred for their simplicity, ease of use, maintenance, and low cost. Experiences clearly demonstrate that the application of technology for persons with disabilities is inexact and will change with time. Changes in the assistive technologies user's health, living environment, preferences, and circumstances will require periodic reassessment by the user and the rehabilitation professionals who are giving assistance [2].

This paper focuses on Serious Games in the rehabilitation area. Rehabilitation, defined as "a set of measures that assist individuals, who experience or are likely to experience disability, to achieve and maintain optimum functioning in interaction with their environments", is instrumental in enabling people with limitations in functioning to remain in or return to their home or community, live independently, and participate in education, the labour market and civic life. Rehabilitation measures are aimed at achieving the following broad outcomes: prevention of the loss of functions, slowing the rate of loss of functions, improvement or restoration of functions, compensation for lost functions and maintenance of current functions [3]. In that sense, one of the fundamental goals of our research was to identify and assess game features that are relevant for rehabilitation process for elder adults. The work herein presented reviews relevant work described in the literature.

The rest of the paper is structured as follows. Section 2 presents an introduction to Serious Games including terminology and concepts. Section 3 introduces the motivation of Serious Games for Rehabilitation for elder adults. Section 4 presents a review of Serious Games for Rehabilitation. Finally, in Section 5, conclusions are drawn and referred future work.

II. SERIOUS GAMES

There are several definitions for serious games, but all have in common the fact that such games have an explicit educational purpose as their priority, rather than serving just for fun and entertainment [4]. However, this does not mean that such games are not or cannot be a form of entertainment [5]. Serious games can be used in various fields such as education, medicine, in the business environment and by the military community. It should be noted that one cannot apply any given game for rehabilitation purposes. As noted in [6], there are games, generally called "common games", that could be interesting for patients, but they present small therapeutic

potential because they generally require rapid responses from the users or complex movements that the patient cannot perform at that moment, thus making their use impracticable. It is therefore necessary to adapt the game to the limitations of the patient [7]. In [8] is expressed the need to customize the experience of the treatment and to make the game highly adaptable, either by means of algorithms that will adapt the game during the session or by the use of predetermined settings defined by the health professional before the session. Although it requires more development time, the real-time adaptive approach with algorithms can provide better results in motivating the patient, for it would be easier to identify his difficulties and modify the game to make it easier to play before it can cause frustration; in the same way, the algorithm could gradually increase the difficulty, for instance, when the game is too easy for the patient, so that he feels challenged and does not get tired of the activity [9].

We can try to differentiate serious games from entertainment games, just as we defined a serious game as being a piece of software combining both “serious” and “game” dimensions, we can define an entertainment game as a piece of software featuring only a “game” dimension.

For serious games, it is more important that the model or simulation can be used to solve a problem, than providing only great ludic experiences of the kind sought by users.

III. SERIOUS GAMES IN THE REHABILITATION PROCESS

Typically rehabilitation occurs for a specific period of time, but can involve single or multiple interventions delivered by an individual or a team of rehabilitation workers, and can be needed from the acute or initial phase immediately following recognition of a health condition through to post-acute and maintenance phases. Rehabilitation involves identification of a person’s problems and needs, relating the problems to relevant factors of the person and the environment, defining rehabilitation goals, planning and implementing the measures, and assessing the effects.

The rehabilitation provided along a continuum of care ranging from hospital care to rehabilitation in the community [10] can improve health outcomes, reduce costs by shortening hospital stays [11], reduce disability, and improve quality of life [12]. Educating people with disabilities is essential for developing knowledge and skills for self-help, care, management, and decision-making. People with disabilities and their families experience better health and functioning when they are partners in the rehabilitation [3].

By using serious games therapy it is possible to provide real-time visual feedback, besides offering a challenge to the patient and strategies that can increase his motivation by giving meaning to the movements being performed [13]. Depending on the necessary equipment, these games can be used by the patient even in the comfort of his own home. But, in order to avoid a complete lack of monitoring by a health professional, serious games can register the patient's performance and/or his movements, making the data available for further medical follow-up [9]. There are several serious games projects, some of them with quite impressive results in the recovery of functionality, while others have not yet had

enough time to yield conclusive results, but have managed to please the patients [14].

In the field of computer games for the elderly, the motivations for elderly people to play games are categorized into areas with entertainment, socializing with other people, mental exercise, and physical exercise [15, 16, 17]. For example, multiplayer games afford the possibility of social interactions while playing games, whereas puzzle and quiz - type games can be used for a purpose similar to crossword puzzles, that is to activate the mind [16, 17]. On the other hand, new user interfaces such as those that track the movements of the player are ideal for physical exercise. There are also serious games that are specifically intended to be used for learning a new skill or improving one’s health [18]. [19]

Table 1 display the motivations for elderly people to play, categorized into areas.

TABLE I MOTIVATIONS FOR ELDERLY PEOPLE TO PLAY GAMES: CATEGORIZED AREAS

Category	Examples
Entertainment	Play for fun purposes
Social	Multiplayer games afford the possibility of social interactions
Mental exercise	Puzzle and quiz-type games for a purpose to activate the mind
Physical exercise	Interfaces that track the movements of the player

Serious games support a specific way of cognitive experience and learning. By solving attractive tasks, experiencing variable learning contexts, repeating the attempts to solve the problems, getting immediate feedback and background information processing can be enhanced. Positive effects on intrinsic motivation, attitude, selfconcept, emotions, perceived control and self-efficacy are also expected [20].

Depending on the interface, the game tasks and the individual experiences, basic or specific sensory-motor skills can be performed [20].

Besides their entertainment value, serious games can have beneficial therapeutic effects for elderly people that improve their health and well-being. With the number of elderly people increasing in the world population, the tools support, designed for this type of public, can contribute to several areas, especially health.

According to [21], over the next 15 years, the number of older persons is expected to grow fastest in Latin America and the Caribbean with a projected 71% increase in the population aged 60 years or over, followed by Asia (66%), Africa (64%), Oceania (47%), Northern America (41%) and Europe (23%).

Figure 1 represents this expected increase of in the population aged 60 and over.

From 2000 to 2015, the number of oldest-old persons in Europe grew to 20%, but between 2015 and 2030, the rate is

projected to 23% for the population aged 60 years or over [21].

In 2050, 44% of the world's population will live in relatively aged countries, with at least 20% of the population aged 60 years or over, and one in four people will live in a country where more than 30% of people are above age 60 [21].

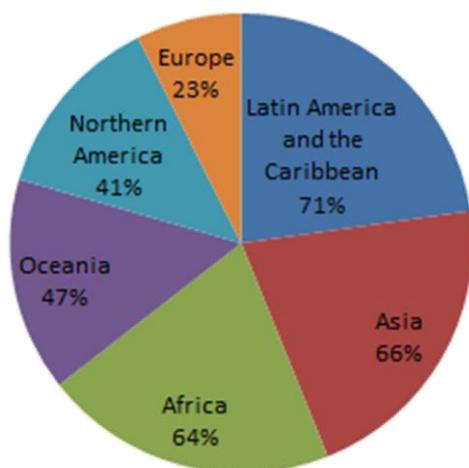


FIGURE 1: INCREASE IN THE POPULATION AGED OVER 60 YEARS

Due to the repetitive nature of exercises, patient motivation is a key problem that has challenged traditional therapy sessions [22].

Computer games design can offer invaluable contributions in the development of more effective games for rehabilitation programs. However, designing a game with all the features that could benefit the rehabilitation process is a complex task. The identification, classification and assessment of game features that are relevant for the health rehabilitation domain are very important for designing rehabilitation games [22].

The most popular technology for therapies with games is the computer. Most of them also are available online for easy access between the therapists and their patients. The first therapeutic game is the Personal Investigator created by [23]. Since this auspicious start, many researchers and therapists have started working on serious games in health care and treatment [24].

IV. REVIEW OF SERIOUS GAMES FOR REHABILITATION

Making physiotherapy sessions more fun is one of the factors that can contribute to patient compliance and improvement of rehabilitation outcomes. In this sense, several games have been developed to make the sessions more enjoyable. The Movement in Virtual Environment for Rehabilitation (MoVER) [14] is a serious game that simulates movements related to physical therapy through challenges to perform virtual tasks with the use of the human body.

The Neurogame therapy [25] was used for the rehabilitation of patients with severely compromised movements. This project did not create a new game and existing games were used, the only difference being the

question of game control. It was selected an integrated circuit with wireless SEMG electrodes (surface Electromyography), such electrodes allowing capturing very small movements, which would be very difficult to capture with the most commonly used devices in serious games with motion controls such as the Wiimote of the Nintendo Wii Console, web cameras or Microsoft Kinect. All patients showed significant improvements after the sessions.

The Handcopter game [26] is a side-scroller game type for rehabilitation of the fingers movement in which the patient must control a helicopter by flexing and relaxing his fingers. As a control it is used a simple webcam placed at a given distance from the patient's hand. A key point in this project was the concern to design the game in order to establish a closer proximity to the patient's life experience, by portraying party balloons used in common street festivities and a landscape where nature prevails. This project aimed at creating a low-cost serious game so it could be easily implemented in Brazil's National Health Service.

PhysioVinci consists of a portable device that can be used both in the clinic and at home, and does not require connection to secondary devices (television or computer), requiring only connection to a power supply. The device consists of two parts, one in the shape of a cylinder, where the speakers are installed and the 3D sensor, the second part with a rectangular prism shape, where the projector, minicomputer and touchpad are installed. The therapist, at an early stage, places himself next to the device, in order to access the touchpad, to handle the game [27].

The NeuroRehabLab has been working in the development of Virtual Reality, Interactive and Serious Games applications. Most of this work has been done under the RehabNet: Neuroscience Based Interactive Systems for Motor Rehabilitation. It consists on technologies from body movement tracking, interactive surfaces, eye controlled, biosensors and brain computer interfaces. To develop a novel upper-limb rehabilitation system that allows not only to effectively train motor function, but to monitor and to collect extensive synchronized brain activity and behavioral data on patient performance during the recovery process [28].

Neurorehabilitation Training ToolKit - NTT consists of a bilateral upper limb task that requires practicing movement smoothness, range of motion, arm displacement and arm coordination. The patient's hand movements are tracked by means of one or two computer mice (there exist support for other interfaces). The physical movements of the patient control the steering direction of a glider that flies forward at a constant speed, accumulating collectable objects. Has the built-in capacity to adjust the training parameters to each patient performance, to avoid stressful/boring configurations, maximize learning, and to maximize user engagement. Further, exploits a simple narrative structure to build a story around the training task to increase the engagement of patients, facilitate the comprehension of the training objectives, and to deliver a clear sense of progress and reward for accomplishments [29].

Vivid Group Gesture Xtreme is a projected video-capture system. Participants stand or sit in a demarcated area viewing

a monitor that displays an environment or functional tasks, such as touching virtual balls. A single camera, vision-based tracking system captures and converts the user's movements for processing. The user's live on-screen video image corresponds in real time to his movements, leading to engagement in the simulated task [30].

In work [31] a set of games was developed for the rehabilitation of stroke patients using Wii Remotes and/or webcam as input devices. What draws attention in this work is the variety of the games developed, including a considerable amount of multiplayer collaborative games. The study suggests that such games may be more motivating, for they have been better accepted than the single player ones.

In order to tackle the problem of adapting the game difficulty to the patient, an algorithm was developed [9] based on the "Ant Colony Optimization" heuristics, inspired by the process ants use to find food. Such approach can improve the patient's experience by using games based on these algorithms at home, since the algorithm itself would change the level of difficulty (lower or higher) without requiring the direct intervention of the rehabilitation technician. Because it is also possible to register the patient's progress, the health professional could be informed of the changes in the level of difficulty and thus carry out a better monitoring of the patient's development.

The existence of several studies in the area of rehabilitation and serious games shows the interest in this subject concerning the development of special serious games for patient rehabilitation [32]. Reinforcing learning through a dynamic model adapted to each user's capabilities in applications that integrate gaming and rehabilitation is an area on the rise. Adapting the game difficulty to the user allows keeping the level of motivation during the rehabilitation process, because the traditional rehabilitation involves repetitive exercises [33].

Healthcare settings are continually being improved, especially regarding the use of the current technologies. In the field of rehabilitation, the use of videogames and related technologies helped develop new rehabilitation procedures [34].

The emergence of devices, such as videogames, that offer movement-based interaction in casual environments has created great interest in their application in healthcare environments. Specifically, rehabilitation processes incorporating physical exercises is one of the main areas where the research community has found a suitable environment for implementing these techniques. The study [35] describes a system, VirtualRehab, which involves physical rehabilitation using motion-based interaction provided by Kinect. The system allows the monitoring and following-up of patients from any location. VirtualRehab's main objective is to offer patients a pleasant way to complete their complex rehabilitation processes at home. To this end, the required equipment includes a personal computer, Kinect for Windows and a projection screen. Furthermore, VirtualRehab contains a management area that allows the medical staff to plan, monitor and evaluate the patient's evolution. The system focuses on specific conditions such as

acquired brain damage, neuromuscular disorders, neurodegenerative diseases and elderly mobility. In order to aid in the treatment of these pathologies, the system places patients in a virtual world where they can work with nine games to perform movements meant to improve specific disabilities. These games allow working with the affected body parts and physical symptoms, particularly in patients with loss of motor skills or movement, posture, balance, and coordination disorders.

In the WiiHab system [35], the technology is once again based on games but it uses the Nintendo technology through the Wii console. Specifically, this system uses the potential of existing Wii games to encourage physical rehabilitation. Some studies [36] provide information on the positive results using WiiHab.

SeeMe [37] is another study on rehabilitation, and in this case corresponds to the evaluation and treatment of unilateral spatial neglect. This system uses another method of rehabilitation that creates a virtual reality environment without requiring specialized equipment. It consists of a video capture projected from a virtual story where a patient is "embedded" by means of her own image. A representation of the patient is generated by capturing her through a camera while performing the activities. Specific algorithms are used for movement and position and recognition analysis. The participant should stand up or sit in a specific area while viewing a screen on which virtual representation is shown during the exercises inside the virtual world. In addition, it allows the healthcare professional to change the system's parameters during the rehabilitation process in order to adapt the exercises and the characteristics according to the patient's progress and needs [37].

The utility and effectiveness of specific serious games in the medical field is always somewhat unclear. This is due to the lack of evidence on the validity of games, as well as the lack of information available to the public. In addition, the insufficient understanding of the design principles between the game developers and the institutions that use a serious game in the medical field compromises its use [37]. Serious games are digital games designed to improve the user's knowledge, skills or attitudes in the "real" world. Serious games applied to medical or health-related purposes are growing in number and types of applications. Serious games-based interventions have been used to support the rehabilitation of disabled patients, thus proving their efficiency as compared with conventional treatment programs [38].

In terms of effectiveness, although the results for serious games designed for those purposes are promising, their implementation as a form of prevention, treatment, or training in healthcare is hampered by a lack of understanding, or even distrust, of the underlying concepts among health professionals. Before physicians and patients consider using serious games as a useful solution to a rehabilitation related problem, it is important that they understand the role, effectiveness and reliability of these games in the therapy process [39]. Studies on the validity and effectiveness of serious games remain scarce [40] [41].

In memory loss situation there are a number of commonly available devices that can help augment the memory of an

individual with a cognitive disability. Clocks, calendars, telephones, personal data assistants, tape recorders, and pagers, when used creatively, can have a great impact on the independence of individuals with cognitive disabilities [42].

Early work on memory aids investigated the application of commonplace technologies, such as clocks and calendars or timers and digital watches. These technologies are inexpensive, easy to use, and have no social stigma that might otherwise be attached to rehabilitation devices. However, these devices have limitations in the amount of information that can be stored and how information can be presented to the user [42].

Cognitive exercises, including computer-assisted strategies, have been used to improve specific neuropsychological processes, predominantly attention, memory, and executive skills. A National Institute of Child Health and Human Development (NIH) Consensus Statement notes that the success of these with studies using global outcome measures also support the use of computer-assisted exercises in cognitive rehabilitation [43].

Making physiotherapy sessions more fun is one of the factors that can contribute to patient compliance and improvement of rehabilitation outcomes. In this sense, several games were developed to make the sessions more enjoyable. The Movement in Virtual Environment for Rehabilitation is a serious game that simulates movements related to physical therapy through challenges to perform virtual tasks with the use of the human body.

Some programs and applications for cognitive training are described below.

PSSCogRehab Cognitive Rehabilitation Therapy System is a system of cognitive rehabilitation therapy, easy to use and disseminated in several research publications as a viable therapeutic tool. It is a cognitive rehabilitation system developed for application by the therapist, individually or in a group. It contains a tool for accessing graphics, additional therapy exercises, selectable menu, administration resources and more. It contains eight therapy modules, which include about sixty-seven computer therapy tasks, most of which contain user modifiable parameters to perform requirement presented by your patient, preinstalled on a Flash Drive, not being necessary installation on the computer, and the system can be transported and used simply on any computer with a USB port. The focus of individual exercises range from visual and spatial skills, memory and attention to problem solving skills ranging from simple to complex. The entity that owns this software also has others in the area of cognitive rehabilitation therapy, such as Cognitive Enhancement Therapy, Neuropsychonline and Challenging Our Minds, the latter two made available online through the use of a browser [44].

Guttmann, NeuroPersonalTrainer, originally developed for the rehabilitation of victims of traumatic brain injury it has been used in patients with neurocognitive disorders. People with dementia suffer from memory loss with other cognitive symptoms, such as speech disorders and difficulty recognizing people, difficulties that have a negative impact on their social

and professional lives. These specific programs arise for the cognitive stimulation of patients diagnosed with dementia or slight cognitive deterioration, creating the possibility of delaying the evolution of these symptoms. Over one hundred and ten specific tasks were developed to stimulate the main cognitive areas: memory, attention, executive functions, language, orientation, calculations and motor control [45].

CogniFit has includes a scientific assessment of the patient's cognitive abilities. Using your database, there is a tool to understand the patient's problem and offer the appropriate brain exercise program. The tasks selected and their difficulty levels are changed dynamically based on needs, allowing the patient to use simple or more complex tools of cognitive stimulation and that information is available to healthcare professionals for use in cognitive rehabilitation [46].

Lumosity's Human Cognition Project is an online platform to facilitate studies on cognitive tools. The mission is to create and validate training tools that aim to improve critical cognitive skills as well as assessment tools to measure cognitive performance. The cognitive rehabilitation tool is available for iOS and Android systems [47].

MindMate, this application offers fun and interactive games to stimulate the user's cognitive abilities. It aims to work memory problems in a stimulating form, personalized and interactive way to improve brain activity [48].

Elude aims to raise awareness for depression and to inform about this dangerous illness. It is specifically intended to be used in a clinical context as part of a psycho-education package to enhance friends' and relatives' understanding of people suffering from depression about what their loved ones are going through. Modeling what depression feels like by contrasting it with other mood states, portrays depression metaphorically. The various parts of the game represent emotional landscapes that correspond to different moods with the gameplay changing according to mood changes [49].

The RehaCom system offers solutions for the training of cognitive functions for healthy people and people with brain dysfunction in different contexts: clinical, institutional or home (teletherapy). Cognitive rehabilitation programs require training to be goal-oriented according to the specific needs of each patient. In this way, cognitive training through the Reahcom system restores or compensates a compromised function. The RehaCom system offers different individual solutions for computerized cognitive training available in several modules, comprising distinct cognitive functions [50].

In recent years serious games have evolved substantially, solving problems in diverse areas. In particular, in cognitive rehabilitation, serious games assume a relevant role. Traditional cognitive therapies are often considered repetitive and discouraging for patients and serious games can be used to create more dynamic rehabilitation processes, holding patients' attention throughout the process and motivating them during their road to recovery [51].

Table 2 displays a comparison of rehabilitation serious games described in this section, according to the criteria, application area, interaction technology and game genre.

TABLE II COMPARISON OF REHABILITATION SERIOUS GAMES

Application Name	Application Area	Interaction Technology	Game Genre
MoVER	Physical therapy	Body movements	Simulation
Neurogame	Physical therapy	Body movements	Simulation
Handcopter game	Physical therapy	Fingers movement	Simulation
PhysioVinci	Physical therapy	Body movements	Simulation
RehabNet	Physical therapy	Body movements	Simulation
Neurorehabilitation Training ToolKit	Physical therapy	Body movements	Simulation
Vivid Group Gesture Xtreme	Physical therapy	Body movements	Simulation
VirtualRehab	Physical therapy	Body movements	Simulation
WiiHab	Physical therapy	Body movements	Simulation
SeeMe	Physical therapy	Body movements	Simulation
PSSCogRehab	Cognitive therapy	Monitor + Keyboard	Memory
C. Enhancement Therapy	Cognitive therapy	Monitor + Keyboard	Memory
Neuropsychonline	Cognitive therapy	Monitor + Keyboard	Memory
Challenging Our Minds	Cognitive therapy	Monitor + Keyboard	Memory
NeuroPersonal Trainer	Cognitive therapy	Monitor + Keyboard	Memory / Simulation
CogniFit	Cognitive therapy	Monitor + Keyboard	Memory
Lumosity	Cognitive therapy	Monitor + Keyboard	Memory
MindMate	Cognitive therapy	Monitor + Keyboard	Memory
Elude	Cognitive therapy	Monitor + Keyboard	Emotional / Simulation
RehaCom	Cognitive therapy	Monitor + Keyboard	Memory / Simulation / Strategy

This comparison was done according with the literature review presented. In the application area criteria, we mention the area in which the system assists in therapy of rehabilitation. In this field, applications can be applied to physical therapy, cognitive therapy or both. The interaction with the system can be carried out using, as resource, the

monitor and keyboard or body movements. As for game genre, the system may support different types of games: simulation, memory, emotional and strategy.

Studies on the impact of serious games on different diseases show a great variety of design and results, as well as suggesting that serious games motivate patients to fulfill the therapeutic requirements, to improve physical fitness and to reduce symptoms of diseases. Taken together, the existing studies show promising tendencies for additional benefits of serious games on the physical and psychological level. [20].

Some specific challenges exist in the area of rehabilitation, according to [20]:

- Selection of appropriate sport or sport-like movements or activities of daily living in order to offer meaningful and motivating exercise contexts for older subjects;
- Construction of adequate training devices offering options that combine challenge and support;
- Determining appropriate effect-response relationships for the different rehabilitation purposes depending on the stage of the disease;
- Development and evaluation of adequate training settings.

V. CONCLUSIONS AND FUTURE WORK

Today's society is turning into a digital society, with the growing influence of the technology in our daily lives. It is present in so many places, sometimes without people realizing it, that being already frequent is considered natural. This society increasingly directs its attention to new technologies, fostering their development and reaching a closer approximation of knowledge, making it increasingly accessible to all.

We conducted a survey of the most relevant work reported in the literature. The studies mentioned represent significant progress in rehabilitation processes through the use of devices and serious games. The research topic arises from the concern to understand and adapt the use of technologies for rehabilitation for elder adults. It is necessary for this age group, increasingly, to rethink how to improve the tools and technological resources, to meet their needs.

Future work aims to relate the patient rehabilitation process with existing technological means and to investigate how this relationship can contribute to a more effective solution in the rehabilitation process because there is a number of a concern, especially the motivational level of the patient, the greater communication throughout the process between health professionals and patients. These and other contributions using the new media aim to create added value and better understand the evolution of the process. Keeping healthy is another interest. We felt that offering technologies which would motivate exercising would be a big asset to the users of this group.

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