Serious Games for Rehabilitation: Requirements for a Collaborative Environment

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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. An example is a collaborative environment, in the broad sense of the word, a place where people from all areas can exchange information about the area under study. So, these possibilities create endless opportunities of use in those games and attract attention from other areas of knowledge. This contribution presents research on environments applied to the rehabilitation, focusing on the elderly. It provides an overview of the use of technological environments by health professionals who perform functions related to the rehabilitation process. For this, a questionnaire and a set of interviews with health professionals of the rehabilitation area were carried out, in order to understand the needs. The study intends to be a support for the future work in this area. The aim of this work is to study and provide a patient-adaptive collaborative environment with recourse to serious games in order to facilitate rehabilitation.**

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. The assistive technologies, according to several studies, enable user to have a better quality of life as well as assist 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 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 [1].

As with other technologies, there has been an increased interest in serious games for elderly people over the last few years. This can be largely attributed to the worldwide increase in aging population. According to [2][3], the proportion of the world's population aged 60 years or over is growing.

This paper focuses on serious games in the rehabilitation area, with emphasis on the study of requirements for an interactive collaborative environment for rehabilitation activities.

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 [4]. In that sense and after the study of several data, such as concepts and numbers associated with the rehabilitation process, an opinion survey was conducted, with the collaboration of rehabilitation centers, as well as health professionals related to this area. To this end, a questionnaire was distributed and interviews were conducted with health professionals with links to the rehabilitation process.

The rest of the paper is structured as follows. Section 2 presents an introduction to serious games in the rehabilitation process including terminology and concepts. Section 3 introduces the motivation of collaborative environment. Section 4 presents suggestions and opinions on the requirements of a collaborative environment, focused in particular on the elderly, through the collection of data from a questionnaire and interviews with health professionals. Finally, in Section 5, conclusions are drawn and referred future work.

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II. SERIOUS GAMES IN THE REHABILITATION PROCESS

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 [5]. However, this does not mean that such games are not or cannot be a form of entertainment [6]. 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 [7], 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 [8]. In [9], it 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 [10].

The rehabilitation provided along a continuum of care ranging from hospital care to rehabilitation in the community [11] can improve health outcomes, reduce costs by shortening hospital stays [12], reduce disability, and improve quality of life [13]. 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 [4].

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 [14].

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 [10]. 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 [15]. Besides their entertainment value, serious games can have beneficial therapeutic effects for elderly people that improve their health and well-being.

As with other technologies, there has been an increased interest in serious games for elderly people over the last few years. This can be largely attributed to the worldwide increase in aging population. According to [16], the proportion of the world's population aged 60 years or over reached 12% in 2013 and this proportion is growing. As a result, we will have more elderly people needing healthcare and support services than ever before [3].

III. COLLABORATIVE ENVIRONMENT

With the development of information and communication technologies, new forms of training and knowledge transfer have emerged and are spreading. Knowledge is accessible anywhere, anytime. To access knowledge does not require being locked in a specific location at a specific time with a specific trainer [17].

The idea of computer supported collaborative learning has been investigated for the last few years. Since a few years, game-based approaches like video games for learning (Serious Games) offer new fields of application [18].

Collaborative environment is often defined by describing it as a construction of shared knowledge through activities with others, where the participants, patients, health professionals or others, are committed to or engaged in shared goals and problem solving. Thus, members of the group are not only engaged in individual activities but also in group interactions such knowledge sharing [19]. This environment offers the opportunity to create a highly social learning environment, characterized by participation and interactivity between elements, for example for both patients and health professionals.

In a collaborative learning environment, knowledge is shared or transmitted among users as they work towards common rehabilitation goals, for example, a shared understanding of the subject at hand or a solution to a problem. These environments offer an opportunity to build social networks linking different stakeholders. This may allow health professionals to use a serious gaming approach to combine the advantages of gaming-based learning with collaborative environments to support the rehabilitation process. However, there are many design challenges that must be addressed in the development of collaborative environments for rehabilitation.

The combination of serious games based learning concepts with collaborative learning may enable new methods. The design of such games, however, is challenging. The gameplay has to fulfill requirements of traditional games (fun, narration, immersion, graphics, sound) and serious games design (seamless inclusion of content, adaptation & personalization). Furthermore, requirements of collaborative environment have to be considered, like communication and a proper group setup [20].

The concept of collaborative learning is being used in various training scenarios today, ranging from mere group works over concepts like mutual teaching to collaborative working on complex projects. Whereas soft skills like the ability to work in teams and to communicate with group members are vital, they can be trained specifically by using collaborative learning principles. So, it seems promising to combine the concept of Serious Games with the concept of collaborative learning. Games, inherently offer many of the

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features which are necessary for collaborative learning to be successful, like common goals, or the necessity to communicate with fellow users [21].

IV. REQUIREMENTS AN COLLABORATIVE ENVIRONMENT

Making therapy sessions more fun is one of the factors that can contribute to patient compliance and improved rehabilitation outcomes. In this sense, a pleasant and focused environment in the area of therapy and the intended audience can complement the dynamics of the sessions.

Patients are not passive receptacles but are active in their process of rehabilitation as they participate in discussions, search for information and exchange opinions. In the same sense, health professionals seek information and exchange opinions with their peers in the area of therapy techniques. Knowledge is co-created and shared among peers. A collaborative environment should be a place where health professionals can participate in interactive rehabilitation sessions with patients in different therapies, as well as with other health professionals from different areas where it is possible to share knowledge about topics of interest, so that they can be help in community and contribute to an evolution of the process of rehabilitation.

After the study of several data, such as concepts and numbers associated with the rehabilitation process, a survey was conducted, with the collaboration of rehabilitation institutions and other professionals in this area of health, in Portugal, through a questionnaire distributed to people performing functions related to the rehabilitation process.

We conducted a questionnaire centered on health professionals with a total of 35 participants of ages between 22 and 46 years of both genders. At the same time, a series of meetings were held with health professionals in a total of 9 interviews. In this case, it is important to point out the importance of these direct contacts and through electronic mail that allow a greater knowledge of the existing reality and in this way a relevant contribution to the creation of the environments.

The purpose of the questionnaire is to characterize the type of needs currently in existence, to analyze opinions that health professionals, family members, patients and other elements related to this area. Through the study it is possible to check opinions and suggestions on existing applications and possible developments. The responses were translated into categories constructed based on the results obtained.

The questions presented were related to the use of Multidisciplinary Collaborative Platforms for rehabilitation purposes. For each of the affirmations, the agreement was asked to evaluate the agreement from 1 to 5, where 1 corresponds to "Strongly Disagree" and 5 to "Strongly Agree". If it was not known what to answer in any statement could indicate "I do not know". If the question does not apply you have been asked to check "Not applicable".

In general, the known platforms present a pleasant and attractive environment for the elderly, with 57.9% with positive levels (3, 4 or 5), emphasizing the 11.8% of higher agreement (levels 4 and 5).

They present good readability, clarity and consistency in an appropriate way to an elderly person, the opinion is shared by 42.1% of the respondents. This shows that there are still needs in presenting these types of environments and platforms for these resources.

Regarding the navigability of the technological tools used, only 42.1% of the professionals interviewed affirm that they are intuitive, simple and efficient. Asked about this fact they suggested as possible improvements resources for environmental control, such as letter increase, color, sound volume, messages with vocabulary, simple and easy, to be understood, possibility to configure the desired level of difficulty, since some tools used are of general use and not specific for rehabilitation.

In the opinion of these professionals, if the platforms used or known can arouse the attention of the elderly and maintain motivation throughout the use of the same, only 36.9% agree, indicating that it is a very specific public and which requires differentiated attention and care.

Only 26.3% of the participants in this questionnaire agree that the known environments are designed specifically for the elderly. However, 57.9% agree that platforms used or known contribute to the process of rehabilitation of the elderly.

In this study, it was also possible to understand that in the opinion of health professionals interviewed, older people have little formal training on how to successfully interact or work with others and that the social milieu of online activities is quite different from in-person interactions, thus requiring new skills and behaviors.

Table 1 displays the levels of agreement to the affirmations in the questionnaire described in this section.

TABLE I. LEVELS OF AGREEMENT TO THE AFFIRMATIONS

Questions **In general, the known platforms present:**	**1 / 2**	**3/ 4 / 5**	**Not know / Not applicable**
A pleasant and attractive environment for the elderly	10,5%	57,9%	31,6%
Present good readability, clarity and consistency	26,3%	42.1%	31,6%
They have intuitive, simple and efficient navigation	26,3%	42.1%	31,6%
They promote the attention and motivation of the elderly throughout their use	26,2%	36,9%	36,9%
Intended for the elderly	36,9%	26,3%	36,8%
They contribute to the process of rehabilitation of the elderly	10,5%	57,9%	31.6%

In addition to the questionnaire, we asked the participants to give feedback in form of critics or suggestions for improvement. The most frequently mentioned were:

- Exchange of opinions among specialists on the most appropriate forms and methods for the treatment of different pathologies (12 / 35)

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- Improvement of character control (10 / 35)
- Allow to adjust everything, for example, letter size, letter color, background color, visual contrast (10 / 35)
- Detailed information about each icon (9 / 35)
- Visual information complemented with auditory information (9 /35)
- Specificities for the study population with games of their interest and difficulty regulation (8 / 35)

New challenges for tools developed for this purpose, such as memory games, physical exercises for patients to do at home or in another place in a family environment, games that stimulate the sensitive and motor part of the patients, the latter ones that deserved more attention and comments.

While collaborative environments and their resources offer much promise for improving therapies outcomes, it is necessary to understand and explore the perceptions of these technologies from the viewpoint of health professionals working in rehabilitation. Numerous factors may influence a professional's decision to adopt this type of intervention in therapeutic practice. An analysis of serious games in rehabilitation revealed a possible of barriers to adoption, including concerns about how to design effective, efficient and easy-to-learn systems, challenges with platform compatibility, immature engineering processes, ethical challenges, limited awareness and unrealistic expectations by therapists, and perceptions this use eliminates the need for therapists [22][23]. These concerns were also mentioned throughout the interviews for this study.

Table 2 displays the concerns and favorable elements mentioned throughout the interviews.

At the end of the interviews and in order to explore the therapists' perceptions, the author presents his ideas about potential technological tools in order to address their needs.

TABLE II. CONCERNS AND FAVORABLE ELEMENTS

Barriers	Facilitators
Increased complexity	Motivation
Older people have little formal training of online activities	Different and customizable interactive sessions
Platform compatibility	New skills and behaviors
Perceptions this use eliminates the need for therapists.	Exchange of opinions among specialists

To date, some research has examined these professionals' views and acceptance of available or rehabilitation-specific gaming technology as interventions [24][25]. Because heath professionals are instrumental in mediating patients' use of technology for rehabilitation, it is pertinent to understand their perceptions. If their views are not understood or incorporated in the development of these technology-based interventions, use may be limited [22]. Thus, one of the purposes of this study were to health professionals perceptions of how use gaming technology in rehabilitation and to identify barriers to the use of these technologies in rehabilitation.

According to Tatla et al. [22], therapists are the key stakeholders who determine the appropriateness of interventions, designing and implementing rehabilitation programs by combining their clinical reasoning with the needs and preferences of their clients. Through this process, they tailor interventions to meet the unique needs of each patient, modify the challenge and difficulty as the client's abilities change, and respond flexibly to the patient's learning and performance needs [26]. These studies indicate the complexities of implementing new technologies in therapy. Despite reporting several challenges with serious games adoption, health professionals interviewed and questioned were open to helping shape the development of serious games and collaborative environments for rehabilitation. Moreover, as an advantage of these tools, they refer to the possibility of increasing adherence to exercise programs against traditional therapy programming.

There is preliminary evidence to suggest positive effects of using a gaming environment compared to conventional therapy [27][28][29]. Several studies have explored the application of technology to promote rehabilitation outcomes [30][31][32].

The collaborative environment should function in such a way that a participant who uses it is aware of the presence of other participants. This puts special emphasis on how participants can contact each other through the use of the system, and how they can keep track of each other's activities and comments and work.

Rehabilitative therapy is usually very expensive and confined to specialized rehabilitation centers or hospitals, leading to slower recovery times for corresponding patients. Therefore, there is a high demand for the development of technology-based personalized solutions to guide and encourage patients towards performing online rehabilitation program that can help them live independently at home [33].

At the end of the interviews, a suggestion of a structure design for a collaborative platform of serious games applied to rehabilitation was presented for discussion, having as a concern its use in elderly people. This environment would be composed of several modules in order to provide a useful tool for its purpose. The "configuration module" of personal needs, such as color and size, was referred by some therapists as interesting and a possible starting point for customizing and motivating patients to their use.

The "presentation module" contains global functions such as the personal area and areas of intervention. The "communication module" contains proximity tools such as email, forum and other relevant elements. It's a module made up of usage data. The "intervention area module" can be customized according to the needs of the patient and type of rehabilitation, cognitive or physical, with connection to the resources module that has adaptive tools such as serious games and exercises. The latter have aroused a greater interest in therapists because, in their opinion, they are possible complementary tools to the conventional treatment.

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Table 3 displays a simple view to the suggestion of structure design for a collaborative platform of serious games applied to rehabilitation.

TABLE III. SUGGESTION OF STRUCTURE DESIGN COLLABORATIVE (SIMPLE VIEW)

Module	Topics
Configuration	Personal Needs • Color • Size
Presentation	Global Functions • Personal Area • Areas of Intervention
Communication	Proximity Tools • Email • Forum • Others
Data	Data Base
Intervention	Cognitive Rehabilitation • Memory Physical Rehabilitation • Mobility
Resources	Adaptive Tools • Serious Games • Exercises

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.

With this study we conducted an opinion survey through questionnaires and interviews with health professionals in this area, in order to verify opinions and suggestions about existing applications and possible developments. The research topic arises from the concern to understand and adapt the use of technologies for rehabilitation. There are some concerns that a collaborative environment must have to support the most relevant and attractive aspects of the elderly public.

Future work aims to relate the rehabilitation process of the patient to the existing technological means and to investigate how that relationship can contribute to a more effective solution in the rehabilitation process, since there are a number of concerns, especially related to the patient's motivation, as well as enabling better communication throughout the process between health professionals and patients.

Contributions that are using the new technologies, with emphasis on collaborative environments and serious games, 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.

The study and design of technologies continue to increasingly provide more specific tools. As a result, we are developing a prototype of a collaborative environment, using serious games that meet the needs, especially concerning the elderly, such as allowing patients to carry out the rehabilitation process in more familiar environments under the supervision of health professionals, but without the need to commute regularly to rehabilitation centers. The study of the prototype also aims to offer new contributions, such as multiple resources in adaptive environments, improve communication between patient and therapist, as well as being a facilitator of rehabilitation with evolution data and different exercises. Several studies have demonstrated that by offering virtual rehabilitation exercises as games, greater efficiency is obtained in the rehabilitation process, and the patients are motivated to perform the rehabilitation exercises and their adherence to the treatment is also greater.

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