State of the Art on Games for Health Focus on Parkinson's Disease Rehabilitation

J. Cancela[1,2], M. Pastorino[2], M.T. Arredondo[2], and C. Vera-Muñoz[2]

[1] CEI Moncloa, UPM-UCM, Madrid, Spain
[2] Life Supporting Technologies Group, Universidad Politecnica de Madrid (UPM), Madrid, Spain

Abstract— **This paper explores current trends and available solutions in the field of games for health focus on Parkinson's disease (PD). According to the Parkinson's Disease Foundation it is estimated that seven to ten million people worldwide are living with PD. Besides this statistics tend to get worse as the population gets older and older. In the last decades the active ageing term has gained extreme importance. As the ageing of the population growths the healthcare policies and strategies need to adapt to this new situation. In that sense, active ageing aims to extend healthy life expectancy and quality of life for all people as they age. Games for health have been proved to be an excellent approach to maintain autonomy and independence for the older people.**

Keywords— **Serious games, games for health, Parkinson's disease, chronic diseases, active ageing.**

I. INTRODUCTION

Chronic diseases are prolonged conditions that normally do not improve with time and are rarely cured completely. Most of these diseases are closely bound with age. Longer life expectancy is directly related with the increasing numbers of people living with chronic conditions, not only one but in most cases two or three chronic conditions at the same time. In almost every country, the proportion of people aged over 60 years is growing faster than any other age group, as a result of both longer life expectancy and declining fertility rates. According to the World Health Organization forecast between 2000 and 2050, the proportion of the world's population over 60 years will double from about 11% to 22%. The absolute number of people aged 60 years and over is expected to increase from 605 million to 2 billion over the same period [1].

This population shift can be seen as a success story for public health policies and for socioeconomic development, but it also challenges society to adapt, in order to maximize the health and functional capacity of older people as well as their social participation and security [1]. At the same time healthcare services that are struggling to cope with the demands of acute care let alone the needs of those with long-term health conditions. Chronic diseases, such as heart disease, stroke, cancer, chronic respiratory diseases and diabetes, are by far the leading cause of mortality in the world, representing 60% of all deaths. Out of the 35 million people who died from chronic disease in 2005, half were under 70 and half were women [2]. A parallel development is the shift away from paternalistic models of health care that sited the patient in the role of passive recipient. The more active involvement demanded by many patients is in keeping with the realities of chronic disease whereby responsibility for day-to-day disease management gradually shifts from health care professionals to the individual.

Parkinson's disease (PD) is a chronic neurological condition that presents primarily as a motoric disorder. PD occurs in about 1% of the population over the age of 60 and its prevalence increases with age. About 20% of people over the age of 80 have Parkinsonism associated gait disturbances. Advancements in treatment for chronic diseases have resulted in reduced length of hospital stay, and in some cases, the avoidance of hospital visits.

Telemedicine brings healthcare delivery to the home environment by connecting the patient with medical professionals. If is not intended to replace health professional care or visits, but rather to enhance the level of care [3]. In the last years several initiatives have been carried out in order to provide an objective tool able to perform a full monitoring and follow-up of PD patients [4–6]. Nevertheless, although home monitoring and patient continuous follow-up will be necessarily two of the keys elements for future healthcare systems, this future also brings changes and duties for the patients. Therefore, patients should play an active role in self-management of chronic conditions. Actually, new policies will focus in the transformation of the patient role not only during the disease but also with a more general scope, the promotion of the active ageing.

Active ageing is the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age. It applies to both individuals and population groups [1]. Active ageing allows people to realize their potential for physical, social, and mental well-being throughout the life course and to participate in society, while providing them with adequate protection, security and care when they need. The word "active" refers to continuing participation in social, economic, cultural, spiritual and civic affairs, not just the ability to be physically active or to participate in the labor force.

II. SERIOUS GAMES AND GAMES FOR HEALTH

Mike Zyda defined serious games as mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives [7]. Serious games can be applied to a broad spectrum of application areas, e.g. military, government, educational, corporate and healthcare [8]. In the healthcare case the most extended term to cover all of them is games for health. We can define serious games as the merge of game technology, other ICT technologies and research areas applied to a broad spectrum of application domains ranging from training, simulation and education to sports and health or any other societal relevant topic or business area.

Apart from the application area, serious games can be also sorted depending on the final purpose of the game. There are games for training, advertising, simulation, or education that are designed to run on personal computers or video game consoles. Games for health applications related to health and healthcare are becoming more and more common every day. Currently there exist a large number of them. Some examples showing the variety of types and areas for applications related to physical or mental health include [8]:

• Physical fitness (also known as "exergaming").
• Education in health/self-directed care. Games can be helpful for patients to adjust their habits and lifestyles to deal with their diseases and to motivate patients.
• Distraction therapy; some games are used as distraction therapeutic tools, for instance, to help chronically ill children to deal with pain, distract them during uncomfortable treatments, or to lessen anticipatory anxiety before medical procedures like surgery.
• Recovery and rehabilitation. Games for health can be used to fasten recovery for certain operations and conditions. They have also been used for increasing motor skills.
• Training and simulation, games can be used for, e.g., surgical training.
• Diagnosis and treatment of mental illness/mental conditions.
• Cognitive functioning; video games as well as traditional games can be used for memory training, development of analytical and strategic skills, etc.

It has been showed that games contribute to increase motivation in rehabilitation sessions, which is the major problem in therapy sessions, caused by the repetitive nature of exercises [9].

With respect to long-term motivation, apart from methods and concepts for personalization and adaptation, multiplayer games can provide additional stimulation compared to single player games [10]. It is important not only to provide an innovative, playful and challenging sports application which arouses the players' interest, but to provide a sustained motivation to keep them playing. Whereas single player games might lose their attraction after being played several times, the competitive aspects in multiplayer games can provide an ongoing and recurrent motivation for the users.

III. CLASSIFICATION AND TAXONOMY OF GAMES FOR HEALTH

Rego et al. proposed a classification schema towards a taxonomy based on a set of criteria for the design of more effective rehabilitation games [9]. We will use this taxonomy to explore the games available for PD rehabilitation. Following a literature review the Rego et al. identified as important the following criteria for the classification of serious games in the rehabilitation area:

• Application area: is the domain application in which game can be applied; despite this domain can be very vast, we may consider however two main applications: cognitive rehabilitation (Cognitive) and physical/motor rehabilitation (Motor).
• Interaction Technology: the technology used by the patient to interact with the system. This can vary from the traditional methods using a mouse or keyboard process to VR based methods. For instance, in VR, interface devices that can be used are: visual interfaces that include head-mounted displays (HMDs) and desktop monitors; haptic interfaces like data gloves; and motion tracking devices.
• Game interface: the interface used in the game. It can be 2D or 3D.
• Number of players: single player / multi-player.
• Game Genre: the games genre can vary in relation with the technology used.
• Adaptability (Yes/No): the system capability to adapt dynamically game difficulty or challenge, according to the patient performance in the game.
• Performance Feedback (Yes/No): this dimension is related with the system capability to transmit to the patient the results of the interaction.
• Progress monitoring: is the capability of the system to allow saving the results of patients' interaction with the system
• Game portability: is related with the capability of the system to be used at home, or at a hospital or clinic.

Table 1: Review of the current systems for PD rehabilitation.

	[11]	[12]	[13]	[14]	[15]
Application	Cognitive + motor	Motor	Motor	Motor	Motor
Interaction technology	Webcam	Infrared camera + body markers	Wii Balance	Wii Balance	Microsoft Kinect
Game platform	PC	PC	Nintendo Wii	Nintendo Wii	PC
Game interface	2D/3D	2D	2D	2D	2D
Number of players at the same time	1	1	1	1	1
Mutiplayer	Yes	N/A	N/A	N/A	No
Game Genre	Mini-games	Mini-games	Assorted	Mini-games	Assorted
Adaptability	No dynamic adaptability. There are different levels	Yes	No	Yes	No
Performance Feedback	Visual + auditory	Visual + auditory	Visual	Yes	No
Patient follow-up	No	No	No	No	No
Game portability	Home + Hospital	Hospital	Home + Hospital	Home + Hospital	Home + Hospital

We have also included some extra considerations in order to extend Rego et al. taxonomy.

• Game platform: the platform where the user runs the game, e.g. mobile, PC or a specific platform.
• Mutiplayer: in the case that the game includes support for multiple players not necessarily playing at the same time.
• Patient follow-up: apart from the games inputs and the scoring system the platform could run a parallel assessment of the patient taking into account the historical information.

IV. GAMES FOR HEALTH ON PARKINSON'S DISEASE REHABILITATION

The search was performed through Google scholar using the terms: Parkinson's disease rehabilitation in combination with serious games and games for health. The search was also extended to related works such as balance and motor assessment based on games:

WuppDi! [11]. A collection of five motion-based games for Parkinson's disease patients, aimed at supporting their exercises routines in various playful environments.

An Interactive Multimedia System for Parkinson's Patient Rehabilitation [12] real-time Multimedia Rehabilitation Environment for the rehabilitation of patients with PD. The system integrates two well-known physical therapy techniques, multimodal sensory cueing and BIG protocol, with visual and auditory feedback to create an engaging mediated environment.

Home-Based Balance Training Programme Using Wii Fit with Balance Board for Parkinson's Disease: A Pilot Study [13]. A home-based balance training programme using visual feedback (Nintendo Wii Fit game with balance board) on balance and functional abilities in subjects with Parkinson's disease.

Assessing and training standing balance in older adults: A novel approach using the 'Nintendo Wii' Balance Board [14]. Using the Nintendo 'Wii Balance Board' (WBB), the authors have developed an interface that allows a user to accurately calculate a subject's centre of pressure (COP) and incorporate it into a virtual environment to create bespoke diagnostic or training programmes that exploit real-time visual feedback of current COP position.

Development of a System for Monitoring and Tracking of Physiotherapeutic Movements in Patients with Neurological Diseases [15]. A friendly software application for monitoring the physical therapy movements of patients suffering from severe motor disabilities.

Table 1 synthetizes the main features of each solution according to our adapted version of the Rego et al taxonomy.

V. Conclusions

Within this work we have introduced different solutions already in use to promote the Parkinson's disease rehabilitation through the use of games for health. It is remarkable the lack of games for mobile platforms such as smartphones. In the recent years the industry of games for mobiles has growth exponentially (both in market and in users); nevertheless, most of the games found related to PD are based on fix platforms i.e. PC or video game consoles. Most of the games focus on the assessment of the motor performance and the repetition of movements following visual and audio cueing. The sensors used as input devices has been improved in the last years thanks mainly to the evolution and the innovative solutions offered by the videogames industry. Both Nintendo WiiBalance and Microsoft Kinect are two powerful input devices for the motor assessment of PD patients. This shift from PC based prototypes to videogames console approach also offer an extra and very relevant advantage. The distribution channel is already implemented and that make easier and eventual transformation from a laboratory prototype to a market product. That's especially relevant when we need to install not only software but some kind of data acquisition devices at patients' home.

Also, although most of the games have shown good acceptance among the patients and the results in terms of rehabilitation outcomes are very promising there is still a lot of place to expand the multiplayer/social part of the games. These features have been showing excellent results in the regular video games during the last years.

Acknowledgment

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Author: Jorge Cancela
Institute: CEI Moncloa
Street: Avenida Complutense 30
City: Madrid
Country: Spain
Email: jcancela@lst.tfo.upm.es