Custom-made exergames for older people: New inputs for multidimensional physical

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***Abstract* —** In this article, we provide an overview of the design and features of a portable exergaming platform with augmented reality components whose intention is to fight the sedentary lifestyle and promote active aging for older people. Exergames are projected on the floor, and the user' movements and gestures are tracked by motion-sensing technology while interacting with the games. By playing the exergames, older adults can work on their physical fitness while training the cognitive function through a rich diversification of stimuli.

Keyword – platform, augmented, reality, active, aging, physical, fitness, cognitive, stimuli, exergaming.

I. INTRODUCTION

Due to the medical advances that have allowed the increase in average life expectancy, modern societies are increasingly aging, consequently creating a need to maintain the quality of life for the elderly [1]. The fight against sedentary behaviors and active aging promotion, are not only a necessity to offer a better quality of life but also to combat the problems commonly associated with the geriatric population [2]. This reality demands adapted specificities to address the challenges related to the elderly age because the existing infrastructures are insufficient to offer services to the increasing senior population [3].

Exergames are video games that combine the possibility of playing and performing exercise at the same time. Exergames are centered on the physical movements and activities of the person and generally blend real-time motion detection with captivating games [4,5]. These games have been studied as an application of technology that can help older people to keep physically active independently [6,7].

This work intends to provide an overview of the design and features of an integrated exergaming portable platform targeting older people. It consists of five customized exergames for older people that were conceived to support functional fitness training on different scenarios (i. e. senior gymnasiums, nursing homes, etc.).

II. METHODS

A. Exergames design

The presented exergames have been designed to provide a positive and significant impact on the players by collecting information on physical function requirements. The Senior Fitness Test framework [8], identifies that the most relevant physical dimensions for this population are motor ability (combining balance, flexibility, and agility), muscular strength and aerobic endurance (integrating both lower and upper limbs, and trunk). By incorporating these dimensions, it was possible to select exercises that were included in the games. Three elements were used as a foundation - physical function requirements, technological setup, and scenario. The design process was performed iteratively in co-creation with end-users and a multidisciplinary team comprised of three videogame designers, three graphical artists, two psychologists, two sports science professionals, five programmers, and three games for health experts. Games were developed under the concept of a trip through Portuguese scenarios (except one of the games which will be further explained in the next section) [9].

B. Setup

As for the technical setup of, the prototype structure, named PEPE (Portable Exergaming Platform for Elderly), consists of a computer, a touch screen, and a Kinect V2 camera in front of the user to capture the user' motion.
Meanwhile, a projector is pointed to the floor to act as a display (Fig. 1).

Fig. 1. PEPE display.

III. RESULTS

The following five games were developed:

Grape Stomping (Fig. 2.A) – with the background of the Douro region of Portugal, it's a predominantly aerobic endurance game, with the goal of shattering grapes, recreating the art of wine production. On a multitasking perspective, the grapes need to be pulled into the wooden vats by executing an arm flexion-extension, so the player can stomp them by repeatedly elevating the knees till reaching a predetermined height, mimicking a march in place exercise. There is additional customization, including different cognitive challenges and the possibility to compete or cooperate with another player at the same time.

Rabelos VR (Fig. 2.B) – This game features the historic wine conveyors Rabelos boats, very common in the city of Porto. The user controls the boat to collect wine barrels from the docks which appear on the margins while avoiding obstacles. The most requested body segment is the upper limb, empowering muscular strength which is promoted by the need to make a rowing motion with the arms to keep the boat moving forward.

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Fig. 2. Exergames.

The lateral movements can be either made from rotating the body or moving sideways with the feet to the margins. To transfer the wine barrels to the boat, the end-user is required to turn the trunk towards the dock and make an extension-flexion movement of the elbow. The intensity of the rowing and the distance between obstacles can be customized.

Toboggan Ride (Fig. 2.C) – inspired on the very famous two-seater wicker sleds from the city of Funchal, this game was designed to request static balance, trunk muscular strength training and a high component of cognitive stimulation. The player drives the toboggan downhill, collecting game points while respecting some traffic rules and avoiding obstacles by moving laterally. To control the toboggan velocity, the player needs to lean the trunk forward or backward to increase or decrease/stop the velocity respectively. The game can be configured adjusting the distance between obstacles, how often obstacles appear, and the controlling mode, which can be by moving sideways or by leaning the trunk laterally.

Exerfado (Fig. 2.D) – with a scenario based on the traditional Fado houses from Lisbon, this game promotes lower limbs muscular strength training and cognitive stimulation. Colored musical notes fall along the same colored lines on a piano keyboard in the foreground. To be successful, the user needs to step on the respective piano key when the musical note hits it. Also, there are special notes, represented as stars with an arrow pointing to which adjacent track they should be moved to, using an arm swipe in that direction to fulfill the task. The game can be customized, by choosing different music, adjusting the percentage of notes to be played, and the notes' speed.

Exerpong (Fig. 2.E) – the only game that doesn't have the Portuguese tradition scenario behind, consists of an exergaming adaptation of the classic pong, with the purpose of training the aerobic endurance. The players control a virtual paddle moving laterally, trying to hit a ball that is bouncing around the game area. The game parameters are diversified, for example, the ball size, the ball speed, and the paddle size.

IV. Discussion

This work shows the creation of a portable exergaming platform as a result of a multidisciplinary team effort towards the development of a set of exergames to promote functional fitness in older people. These efforts ensured the creation of appealing exergames for older people to play, choosing activities, and settings. The design process combined aspects that older adults were attracted to and the feedback provided by end-users and sports professionals from multiple testing sessions.

The five exergames prototypes were tested in a senior gym, supporting a 3-month controlled longitudinal study with 31 healthy independent older adults (22 females; age: M=67,5, SD=4,6). To evaluate the physical fitness and cognitive levels, three evaluations were made throughout the study (initial, intermediate and final), using COGTEL for the cognitive measure and the Senior Fitness Test battery of Rikli & Jones to assess the physical. Results showed that people that were on a program that combined exergames with traditional fitness training had strength gains in the upper, lower limbs, handgrip strength, balance, and cognitive functions.

Additionally, it was possible to personalize games at different levels of difficulty to match the level of physical fitness of the players. For future work, there is a need to validate the exergames for people with physical impairment, customizing the game parameters according to those limitations. For this reason, we are currently testing the system with older adults with motor disabilities, and we are collecting qualitative feedback to understand how the exergames can be better customized to this population.

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References

[1] Nations, U. (2015). World Population Ageing 2015. United Nations, Department of Economic and Social Affairs, Population Division

[2] Udayshankar, P. M., & Parameaswari, P. J. (2014). Healthy and active ageing. World Applied Sciences Journal, 30(7)

[3] Bloom, D. E., Jimenez, E., & Rosenberg, L. (2011). Social Protection of Older People. PROGRAM ON THE GLOBAL DEMOGRAPHY OF AGING, (83). Retrieved from http://www.hsph.harvard.edu/pgda/working.htm

[4] Pompeu JE, Arduini LA, Botelho AR, Fonseca MBF, Pompeu SMAA, Torriani-Pasin C, et al. Feasibility, safety and outcomes of playing Kinect Adventures!TM for people with Parkinson's disease: a pilot study. Physiotherapy [Internet]. 2014 Jun [cited 2017 Mar 27];100(2):162–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0031940613001223

[5] Barry G, Galna B, Rochester L. The role of exergaming in Parkinson's disease rehabilitation: a systematic review of the evidence. J Neuroeng Rehabil [Internet]. 2014 Mar 7 [cited 2018 Jul 27];11:33. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24602325

[6] Anderson-Hanley, C. et al., 2012. Exergaming and Older Adult Cognition: A Cluster Randomized Clinical Trial. Am. J. Prev. Med. 42, 109–119. doi:10.1016/j.amepre.2011.10.016

[7] Molina, K.I. et al., 2014. Virtual reality using games for improving physical functioning in older adults: a systematic review. J. NeuroEngineering Rehabil. 11, 156. doi:10.1186/1743-0003-11-156

[8] Rikli, R.E., Jones, C.J., 2013. Senior Fitness Test Manual. Human Kinetics,927–928. http://doi.org/10.5829/idosi.wasj.2014.30.07

[9] Gonçalves, A., Muñoz, J., Gouveia, E., Cameirão, M. S., & Badia, S. B. i. (2017). Portuguese Tradition Inspired Exergames for Older People - Strategic Tools to Promote Functional Fitness. In *icSports 2017*.