

Eldergames: Videogames for empowering, training and monitoring elderly cognitive capabilities.

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Abstract— Recent solutions offered by Information and Communication Technologies (ICT) in elderly care and interventions have reached considerable levels of effectiveness; an emerging new approach to psychological, cognitive and neuropsychological rehabilitation is represented by the use of interactive applications such as videogames. Eldergames is an EU funded project aiming at developing a system to enrich the quality of life of elderly people, through an interactive tabletop solution, while simultaneously trying to reduce the natural physical and cognitive decline derived from aging. The paper considers the benefits of a cognitive training performed via videogames, and describes the solution offered by the Eldergames system.

I. INTRODUCTION

THE great increase of old population, and of the ensuing economic and social costs represent an urgent issue that contemporary society should address with proper plans [1]. When compared with the global population, the European one results to be the oldest: its median age is 39 [2], with concerning estimates for the next 20 years, when old people will be more than 1.2 billion [3].

The increase of the percentage of the old population has implications for the society as much as for the individuals; as a general datum, it has been estimated that up to 50% of people aged over 85 suffers from a cognitive decline [4]. The aging process involves changes in the physical and

mental apparatus of a human being; the pathologies connected to aging range from mental impairments (affecting for example perception, attention, learning, memory, thought, language) to physical difficulties (related to vision, hearing, mobility and general motor movements). Impairments and disabilities affecting old people are accompanied by functional limitations, namely by the inability to perform specific tasks, and by the decrease of the individual autonomy and independency from the help of others [5].

In order to address these issues and to facilitate the so-called “successful aging” a strong contribution could derive from assistive technology, which could help in various ways: by monitoring health status and utilizing alerts in case of problems (assurance systems), by supporting daily activities (compensation systems) [6], by reducing impairments, and evaluating cognitive status (assessment systems) [7]. In recent years, numerous and different kinds of technologies have been used to address age-related problems: personal service robots for old people to both provide information about daily activity and keep in touch with family and caregivers through telepresence [8]; remote ICT systems measuring environmental parameters, such as sleep patterns or use of cooking, as indices of functional health [9]; innovative technological health and independence maintenance systems [10]; personal assistants to help old or disabled people [11]; the use of VR for rehabilitation [12]; health care technologies [13].

Videogames are a computer technology that has received special attention in the last years. In fact, interactive applications like videogames, in which rapidly running images require control and concentration on different objects, can stimulate peripheral processing, with benefits to the normal functionalities of the nervous system. The positive effects of playing videogames have been underlined by several researches. For example, studies have demonstrated improvements in cognitive and perceptual capacities [14] and in visual selective attention [15] in gamers compared to non-gamers; cognitive improvements have been reported in spatial skills and reaction times [16]. Videogames have been also shown to positively stimulate learning, because of their ability to act on motivation [17]. Designing and developing specific videogames applications for elderly population could enable them to enjoy themselves and, at the same time, to undergo a training, without getting scared by task complexity or being bored.

In the next section, we will present some videogames

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designed as training tools to old users.

II. VIDEOGAMES FOR ELDERLY

Originally considered as a form of entertainment directed to specific users, i.e. young people, videogames are now considered as a tool with more than a purely entertaining function [18]. They have demonstrated their positive effects on learning, by acting on motivation [“edutainment” 17]; on visual capabilities, improving players’ selective attention [19]; on cognitive abilities [20][21]. Therefore, they can work as rehabilitation tools [22], for disorders like anxiety [23], or acrophobia [24].

One increasing application area is to use them as cognitive training systems. A cognitive training is a continuous exercise on some particular abilities in order to help re-acquire useful levels of performance in specific tasks. Cognitive training on elderly in general has long-term positive influences [25][26] and benefits on episodic memory [27][28], visual processing speed [29], reasoning abilities [30], problem solving [31] and cognitive impairments [32] such as schizophrenia [33]. Videogames have been used as cognitive training for elderly since the mid ‘80: e.g. Pac Man and Donkey Kong [34], Crystal Castle [35], Super Tetris [36], Free Cell [37], Brickles and Concentration [38]. In the last years, several games have been proposed, addressing different types of cognitive impairment connected to aging. For example, VAE (virtual augmented exercise) [39] was recently used as a collection of cognitive exercises in substitution of similar physical traditional ones, and results showed considerable benefits for the users. Some rehabilitation tools are characterized by augmenting the mediated experience, and are particularly useful for mild stroke or chronic patients, like VividGroup’s Gesture Xtreme™ and Sony PlayStation II Eye Toy [40]. Other games, like Nintendo DS and Nintendo Wii [41], allow users to manipulate virtual objects in a natural way. Finally, some applications are directed towards specific cognitive functions such as memory [42][43] or visual attention.

Another important area of application for videogames is the treatment of psychological and social troubles derived from aging (as a direct or indirect consequence of cognitive changes emerging in this period of life). One of the most important and worrying age-related problem experienced by elderly is social isolation. Because of their physical disabilities or other age-related problems, they are often isolated from their familiar, cultural and social context, in a negative loop in which a physical impairment leads to a social problem, which has physical rebounds and so on. The social engagement of elderly is consequently very important to maintain and promote wellbeing, from all points of view, and videogames can offer their contribution. Age-Invaders is an example of a videogame able to stimulate intergenerational interactions, where grandfathers/mothers can play games with grandchildren, and being followed by parents through an Internet connection. In the last years, many other tools have been developed to address the elderly social isolation problem,

enabling them to maintain their relationships with family, friends or caregivers [44], to improve social contact and affective experience with peers, under the supervision of caregivers [45] or by engaging in physical and amusing activities, like dancing [46].

All the applications and systems described above with their positive effects and results can be assumed as the start point inspiring the innovative solution presented in the next section, Eldergames.

III. ELDERGAMES PROJECT

Supported by EU funds and managed by several European companies, recreation centers and universities, ElderGames [44] is developing a solution to enhance elderly quality of life through an interactive tabletop system, combining easy-to-use design and shared entertainment (*Figure 1*). The system is mainly addressed to mentally healthy individuals to prevent the onset of mental diseases, and to reduce the natural cognitive decline. Different cognitive abilities such as memory, attention and perception are trained and monitored by experts and specialists in gerontology and elderly care



Fig. 1. Prototype of the Eldergames table.

As shown in Figure 1, the interactive table accommodates four people around it. One of the most interesting characteristics of the platform is the possibility to join the game from a different location, through a normal Internet connection; an iconic communication system helps overcome linguistic barriers, enabling a shared game experience with people from different countries.

The system includes two different game areas: the main one is represented by a classic memo game, in which the final goal is to pair cards of the same type (*Figure 2*); the second one collects a series of games, chosen by therapists on the basis of the users’ training needs. This latter section enables experts to monitor any progress or degeneration of cognitive skills. Collaboration or competition characterize alternatively some sections of the game, with the intent to

stimulate social interaction; finally, a specific system of positive and negative feedback in the form of bonus and penalty regulates the progression in the game.

The physical interaction with the table is allowed by an innovative mixed-reality system in which players use real objects, such as pens, or cubes, to answer or manipulate digital objects on the screen; this fusion between virtual and real has the potential to make the platform usage more natural, following a trend already established in entertainment products.



Fig. 2. Players facing the Memo game module.

IV. CONCLUSION

Entertaining and training represent the two combined goals of Eldergames system; on the one hand, they contribute to improve older users' functional independence and social relations, on the other hand they permit experts, through a constant supervision, to collect new data about their patient's physical and cognitive conditions. Trials in three different European countries are taking place while we're writing this note.

REFERENCES

- [1] Nehmer, J., Karshmer, A., Becker, M., Lamm, R. (2006). Living Assistance Systems –An Ambient Intelligence Approach. *International Conference on Software Engineering*, 43-50.
- [2] Population division of the department of economic and social affairs of the United Nations secretariat (2007) *World Population Prospect: The 2006 revision highlights*. New York. United Nations.
- [3] World Health Organization (2007) Active Aging: A policy framework. Retrieved on 5 december 2007 from http://whqlibdoc.int/hq/2002/WHO_MNH_NPH_02.8.pdf
- [4] Anderson 1999.
- [5] Cutler, D.M. (2001). The reduction in disability among the elderly. *Proceedings of the National Academy of Sciences of the U S A*, 98(12), 6546–6547.
- [6] Lawson S., D. Nutter (2006) Augmented Reality Interfaces to Support Ageing-in-Place. British HCI 2006 http://www-edc.eng.cam.ac.uk/~jag76/hci_workshop06/lawson_et_al.pdf
- [7] Pollack, M.E. (2005). Intelligent technology for an aging population. *AI Magazine*, 26 (2), 9-24.
- [8] Baltus, G. et al (2000). Towards personal service robots for the elderly. In *Proc. AAAI Workshop Interactive Robotics and Entertainment*, Apr. 2000.
- [9] Celler, B.G. et al. (1995). Remote monitoring of health status of the elderly at home. A multidisciplinary project on aging at the University of New South Wales. *International Journal of Bio-Medical Computing* 40, 147- 155.
- [10] Dishman, E.(2004). Inventing wellness systems for aging in place. *Computer* 37, 5 (May 2004), 34–41.
- [11] Nortman, S.D., Arroyo, A., Schwartz, E.M. (2000). *Omnibot 2000: Development of an Autonomous Mobile Agent for the Disabled and Elderly*. Florida Conference on Recent Advances in Robotics May 4-5, 2000, Florida Atlantic University.
- [12] Sveistrup, H. (2004). Motor rehabilitation using virtual reality. *Journal of NeuroEngineering and Rehabilitation*, 1-10.
- [13] Cmarinha-Matos, L., Afsarmanesh, H. (2004). TeleCARE: collaborative virtual elderly care support communities. *The Journal of Information Technology in Healthcare*, 2 (2), 73-86.
- [14] Green C.S., Bavelier D. (2006). The Cognitive Neuroscience of Video Games. In Messaris, P & Humphreys, L. (Eds). *Digital Media: Transformations in Human Communication*, pp. 211-224. New York, Peter Lang.
- [15] Green, C.S., Bavelier D. (2003). Action video game modifies visual selective attention. *Nature*, 423, 534-537.
- [16] Lager A., Bremberg S. (2005) "Health Effects of Video and Computer Game Playing—A Systematic Review of Scientific Studies." Report, National Swedish Public Health Institute.
- [17] Prensky, M. (2003). Digital game-based learning. *ACM Computers in Entertainment*, Vol. 1, No. 1, October 2003, Book 02.
- [18] Gamberini, L., Alcaniz, M., Barresi, G., Fabregat, M., Prontu, L., and Seraglia, B. (2008). Playing for a real bonus: Videogames to empower elderly people. *Journal of CyberTherapy & Rehabilitation*, 1(1), 37-48.
- [19] Green, C.S. & Bavelier, D. (2007). Action video game experience alters the spatial resolution of attention. *Psychological Science*, 18(1), 88-94
- [20] Gaggioli, A., Gorini, A. and Riva, G. (2007). Prospects for the Use of Multiplayer Online Games in Psychological Rehabilitation. *Proceedings of Virtual Rehabilitation*, 27-29 September, Venice, Italy.
- [21] Koeppe, M.J., R.N. Gunn, A.D. Lawrence, V.J. Cunningham, A. Dagher, T. Jones, D.J. Brooks, C.J. Bench, and P.M. Grasby. (1998). Evidence for striatal dopamine release during a video game. *Nature* 393:266-268.
- [22] Cameirao, M.S., Bermúdez i Badia, S., Duarte Oller, E., Zimmerli, L. and Verschure, P.F.M.J. (2007). The Rehabilitation Gaming System: A virtual reality based system for the evaluation and rehabilitation of motor deficits. *Proceedings of Virtual Rehabilitation*, 27-29 September, Venice, Italy.
- [23] Krijn, M., Emmelkamp, P.M.G., Olafsson, R.P., and Biemond, R. (2003). Virtual reality exposure therapy of anxiety disorders: a review. *Clinical Psychology Review*, 24 (3), 259-281.
- [24] Jang, D.P., Ku, J.H., Choi, Y.H., Wiederhold, B.K., Nam, S.W., Kim, I.Y., and Kim, S.I. (2002). The development of virtual reality therapy (VRT) system for the treatment of acrophobia and therapeutic case. *Information Technology in Biomedicine, IEEE Transactions on*, 6 (3), 213-217.
- [25] Sherry, L.W. et al. (2007). Long-term effects of cognitive training on everyday functional outcomes in older adults. *JAMA*, 296 (23), 2805-2814.
- [26] Karlene, B. et al. (2002). Effects of cognitive training interventions with older adults. *JAMA* 288 (18), 2271-2281.
- [27] Belleville, S., Gilbert, B., Fontaine, F., Gagnon, L., Ménard, E. and Gauthier, S. (2006). Improvement of Episodic Memory in Persons with Mild Cognitive Impairment and Healthy Older Adults: Evidence from a Cognitive Intervention Program. *Dementia and Geriatric Cognitive Disorders*, 22, 486–499.
- [28] Gunther VK, Schafer P, Holzner BJ, Kemmler GW (2003): Long-term improvements in cognitive performance through computer-assisted cognitive training: a pilot study in a residential home for older people. *Aging Ment Health*; 7: 200–206.
- [29] Roenker, Gayla M. Cissell, Karlene K. Ball, Virginia G. Wadley, Jerri D. Edwards (2003) Speed-of-Processing and Driving Simulator Training Result in Improved Driving Performance.
- [30] Willis S.L., Tennstedt S.L., Marsiske M., Ball K., Elias J., Koeple K.M., Morris J.N., Rebok G.W., Unverzagt F.W., Stoddard A.M., Wright E.W. (2006). Long-term Effects of Cognitive Training on Everyday Functional Outcomes in Older Adults. *The Journal of the American Medical Association*, 296:2805-2814.
- [31] Stine-Morrow E.A.L., Parisi J.M., Morrow D.G., Greene J., Park D.C. (2007). An Engagement Model of Cognitive Optimization

- Through Adulthood. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, 62: 62-69.
- [32] Morales-Sanchez A., Arias-Merino E., Diaz-Garcia I., Cabrera-Pivaral C., Maynard-Gomez W. (2007). Effectiveness of an educative intervention on operative memory through popular games in the elderly. *Alzheimer's and Dementia*, 3(3): S127-S127.
- [33] Twamley, E.W., Dilip, V.J., Bellack, A.S. (2003). A review of cognitive training in schizophrenia. *Schizophrenia Bulletin*, 29 (2), 359-382.
- [34] Clark, J.E., Lanphear A.K., Riddick C.C. (1987). The effects of videogame playing on the response selection processing of elderly adults. *Journal of Gerontology*, 42 (1):82-85.
- [35] Drew D. and Waters. J. (1986). Video games: Utilization of a novel strategy to improve perceptual motor skills and cognitive functioning in the non-institutionalized elderly. *Cognitive Rehabilitation*, 4:26-31.
- [36] Goldstein, J. H., Cajko, L., M., Michielsen, M., vanHouten, O, Salverda, F. (1997). Video games and the elderly. *Social Behavior and Personality*, 25(4):345-352.
- [37] Jimison, H. B., Pavel, M., McKanna, J., Pavel, J (2004): Unobtrusive monitoring of computer interactions to detect cognitive status in elders. *IEEE Transactions on Information Technology in Biomedicine* 8(3), 248-252
- [38] Bailey, S. et al. (1989). Experimental computer based study at Lowman Home. University of South Carolina, College of Social Work. In Whitcomb, G.R. (1990). Computer games for the elderly, *Proceedings of the conference on Computers and the quality of life*, Washington, D.C., United States, September 13 - 16, 1990,112-115.
- [39] Van Schaik, P., Blake, J., Pernet, F., Spears, I., Clive Fencott, C. (2008) Virtual Augmented Exercise Gaming for Older Adults *CyberPsychology & Behavior*. 11(1): 103-106.
- [40] Kizony R., Weiss P.L., Shahar M., D Rand D.(2006). TheraGame: A home based virtual reality rehabilitation system. *International Journal on Disability and Human Development*, 5(3):265-269.
- [41] Nintendo Wii <http://www.touchgenerations.com>
- [42] Brain Fitness Programm™, <http://www.postscience.com>
- [43] Mahncke H.W., Connor B.B., Appelman J., Ahsanuddin O.N., Hardy J.L., Wood R.A., Joyce N.M., Boniske T., Atkins S.M., Merzenich M.M.(2006). Memory enhancement in healthy older adults using a brain plasticity-based training program: A randomized, controlled study. *Proceedings of the National Academy of Sciences*, 103(33): 12523-28.
- [44] Mikkonen, M., Vayrynen, S., Ikonen, V., and Heikkila, M.O. (2002). User and concept studies as tools in developing mobile communication services for the elderly. *Personal and ubiquitous computing*, 6, 113-124.
- [45] Morris, M.E. (2005). Social Networks as health Feedback Displays. *Internet Computing, IEEE*, 9 (5), 29-37.
- [46] Keyani, P., Hsieh, G., Mutlu, B., Easterday, M., & Forlizzi, J. (2005). DanceAlong: Supporting Positive Social Exchange and Exercise for the Elderly Through Dance. *In Extended Abstracts of the Conference on Human Factors in Computing Systems (CHI'05)*, April 2005, Portland, OR, USA.
- [47] Eldergames Project <http://www.eldergames.org/index.php>