

Game based Learning to Enhance Cognitive and Physical Capabilities of Elderly People: Concepts and Requirements

Aurelie Aurilla Bechina Arntzen

Abstract—The last decade has seen an early majority of people. The last decade, the role of the of the information communication technologies has increased in improving the social and business life of people. Today, it is recognized that game could contribute to enhance virtual rehabilitation by better engaging patients. Our research study aims to develop a game based system enhancing cognitive and physical capabilities of elderly people. To this end, the project aims to develop a low cost hand held system based on existing game such as Wii, PSP, or Xbox. This paper discusses the concepts and requirements for developing such game for elderly people. Based on the requirement elicitation, we intend to develop a prototype related to sport and dance activities.

Keywords—Elderly people, Game based learning system, Health systems, rehabilitation

I. INTRODUCTION

THE last decade has seen an early majority of people in European countries using the computer and internet in support of their everyday life and social contacts. The social use of Information communication and technologies (*ICT*) is defined as a daily personnel and local use of ICT for stimulating social, cultural and business activities and networks by individual citizens [1].

Although, it is well recognized that the social use of ICT can contribute to a competitive and vital society, there is still a need to understand the social use of the ICT and to investigate the factors hampering the effective use of the ICT in various aspect of the human life such for example in the medical field. For instance, according to a medical review [2], a large number of people experiencing a stroke are mostly elderly who require locally based multi-disciplinary assessments and appropriate rehabilitative treatments after they are out of the hospital. Therefore, this generates a high request on healthcare services, and an increase expense in the National Health Service. The aim of rehabilitation is to allow a person who has experienced a stroke to regain as much as possible their independence. However, the recovery characteristics depend not only of the severity of the stroke but as well of the patient's needs and progress. Despite the facts that most of the functional abilities can be recovered soon after stroke, quite often home-based rehabilitation is needed and requires an adaptive approach in order to correct unwanted motion behavior or restore a right movement. For example, in

rehabilitation process, the movement of stroke patients require to be detected and analyzed in order to correct it, in case it is wrongly performed [3]. Thus, tracking these movements becomes vital and necessary during the course of rehabilitation.

It is commonly agreed, amongst the medical practitioners, that virtual rehabilitation can provide therapists with new tools to perform their tasks in more effective way by better engaging patients who can potentially lack interest or motivation to complete normal exercise. However, the high cost of many existing systems prevents the widespread deployment in outpatient clinics or patients' homes. Therefore, it is important to determine ways to make innovative treatments accessible to most patients. Today, it is acknowledged that the use of gaming technologies and Virtual Reality (VR) in healthcare could potentially contribute to enhance a physical therapy session, Alzheimer's treatments, stroke rehabilitation and so forth.

In addition, the problems of an aging population are a growing concern for today society. As the ratio of retired people to workers increases, there is a stringent need for more medical and care giving services. The high cost of long-term care for the elderly is contributing to a tremendous financial burden for not only the family members but as well for public health service. Therefore, it is important to investigate mechanisms to keep the elderly healthy and self-sufficient both for the quality of life of retired people as well as to contain the generated cost. In an attempt to improve the quality of life for the elderly, rehabilitation after injury or stroke, maintaining cognitive ability are becoming an increasing focus for the health sector. One of the main problems for physical or cognitive rehabilitation programs is compliance. How to motivate the patients to perform intellectual or physical exercises? Training Game play system or Exergame system could answer to these concerns.

The aim of our project is to develop a game play system contributing to enhance the cognitive and physical abilities of disabled or elderly people. This paper describes the socio-economical and technical requirements for developing such a game. Based partially on the identified requirements, a game prototype dedicated for elderly people is outlined. The next section of the paper, discusses the general concepts of gaming and health. The section three presents the context of the study and outline a model delineating the general requirements for developing game based system for elderly or disabled people.

Aurilla Aurélie Bechina is with the Buskerud College University, Kongsber, 2603 Norway (phone: +47-92490497; fax: +46-32; e-mail: aurillaa@hibu.no).

II. GAMES AND HEALTH

For many years computer games have been seen merely as distractions for children. Part of the power of computer games to distract is due to their ability to motivate. The last few years, there has been a significant change in the way in which the players interface with the game [4]. For example, games such as Nintendo Wii has provided a wider range of game inputs. These games do not require sitting front of computer screen or using some multimedia device in a static way. In contrary, the gamers should stand front of the screen and play more actively. This is both very social as well as being motivational. In addition, the integration of innovative technologies such as motion sensors, Movement tracking camera, virtual realities and 3D user interfaces with games consoles, has opened up a whole new range of gaming systems leading to the concept of Exergaming.

The first commercially successful Exergame was Konami's Dance Dance Revolution™ (DDR). It combined the fun of arcade games with the benefits of dance and physical exercises. Dance Dance Revolution used a sensory surface for musical dance games and included music. The game featured as well the possibility to play in team giving a sense of socially competitive participation [ref]. The game was then developed for home use; the public did not adopt it mainly because of the high cost but as the quality of home dance mats were poor. The game was used specifically by young and fit people. The success has inspired the development of another game "dancetown" dedicated to older people.

The Dancetown Fitness System® aimed at improving quality of senior life for adults. This gaming system uses a dance pad marked with directional arrows. A computer connected either to a screen or a television, is linked to the pad. When the user starts to play, graphics showing the steps are displayed on the screen. The level of progression is done step by step. Since the game is designed for senior, the dance is performed on slow mode. The interest of the game relies as well on some specific feature such as senior-specific assessment tools including the Senior Fitness Test.

The Sony PlayStation® 2 EyeToy™ is a low-cost, off-the-shelf, video-capture system. It consists of a camera connected to the PlayStation 2 gaming system, which is connected to a television. The player is able to interact with the system through a camera, the screen displaying captured movement of the users. Players move their bodies to "play" different virtual games, such as popping bubbles, painting a rainbow and so forth. Some research studies have been conducted in order to assess whether the EyeToy system could be used in rehabilitation post-stroke [5]. The purpose of the study was to explore the feasibility of using a Virtual Reality gaming device (Sony EyeToy: Play 2 on a PlayStation 2) to improve function two years after stroke for an patient who has exhausted all traditional rehabilitative interventions. The study concluded that the device was quite feasible. The patient claimed that it enjoyable to use and believed in getting better.

In 2008, Nintendo has released a new Wii console and Wii Fit platform aimed for children attracted by casual, sports, and exercise games.

The console employed wireless accelerometer-based controllers that allowed natural intuitive movements. Research studies were conducted in order to evaluate the potential exercise benefits. According to [6], while teens playing active computer games, spend more energy than playing sedentary computer games, they still don't use as much energy as playing the sport itself. The research study concludes that playing with active Wii Sports games was not enough to comply with the need of children exercise. However, another study was more positive by stating that Energy expenditure during active video game play is comparable to moderate-intensity walking and may have the potential to increase free-living physical activity [7], [8]. Therefore, for teens that spend significant time playing video game for entertainment, physically active games could be seen as a safe and enjoyable way to promote energy expenditure. Yet, there was an emphasis on conducting larger intervention trials to provide definite answers as to whether this technology is effective in promoting long-term physical activity in children [8]. Today, they are several type of game, and the last couple of years have seen a new trend in providing game specifically designed for the senior's people, including baseball games and golf games. These games use Wii Remote control and can be set up by the nurse in aged care environment. The outcomes of a European Research project "eldersgame", stated that sports games could help seniors to exercise efficiently their arms and waist. In addition, other games such as Dancing Carpet allow the senior to dance on the carpet to exercise their knees, calf and toe muscles. Seniors could use the Wii Fit to play Yoga and other games to improve their balance and strengthen knees and ankles [4]. In addition, some others game have proved to enhance cognitive ability by stimulating mental activities. This is stated in several studies[9], [10],[11]. For example, according to [4], New evidence from the Alzheimer's Society suggests that the progression of Alzheimer's can be slowed by the use of computer-based puzzles. Puzzles are being used more and more often as a tool for psychomotor activity therapies since they contribute to help with spatial orientation, visual-motor coordination and visual perception.

Thanks to the controller able to track spatial movement, The Nintendo Wii is perceived as an ideal tool for the elderly [4]. However, Microsoft released their new product Xbox 360 'Project Natal', which can be operated without controller. This new trend in Exergaming is based on real-time depth-sensing camera systems with embedded three-dimensional skeletal tracking such as Microsoft Kinect™. The main concept lies on the fact that the player is the controller, thus providing a real interactive gaming environment. Users can navigate through menus by using body gestures. Its inbuilt camera enables facial and voice recognition. The features are promising for senior as, they don't have to use any type of controller. They just have to do the movement while the sensors and camera are capturing users' gestures, actions and Voice. However, since it is new technology, there is a need to investigate if game based on Kinectic technologies would help to contribute to enhance physical and cognitive abilities of elderly people. This type of audience has different type of requirements compared to teens or younger people that are usually healthier. Most of the

current games are not really adapted to elderly or disabled people; therefore, it is important to investigate the functional and non functional requirement before designing a specific game system. In the next section of the paper, requirements are defined and analyzed.

III. REQUIREMENTS FOR TRAINING GAME

A. Context of study

Game developers have expanded their demographic by offering new games attracting different people ranging from elderly, women and so forth [11]. New gaming systems have been seen as potential tools by physiotherapists and the health professionals. However, developing new games require the understanding of the cognitive and physical abilities of elderly people that usually decline with the age. In Norway, the number of elderly aged 65 is increasing at high pace. A third of the elderly will have no significant functional impairment. However, more than half will need assistance for four or five years because of dementia (20 per cent) or other diseases (36 per cent). Dementia is not a single specific disease but rather a range of diseases characterized by impairment of brain functions resulting in restrictions in language, memory, perception, personality, cognitive skills and activities of daily living. The most common type of dementia is Alzheimer's disease. There is currently no cure for dementia and it is the greatest single contributor to burden of disease. Because dementia is a disabling health condition a large proportion of people with advanced dementia require full-time care and live in a residential aged care facility. People with dementia might feel loss of self control leading in some cases to loss of self confidence and motivation. However, recent research studies indicate that people could avoid a full decline of cognitive or physical abilities if, they are motivated to exercises their brain and body. According to [12], playing Bingo in some cases could enhance mental stimulation that is highly therapeutic by allowing the brain to make new neurological connections [12]. A computer based game called *Smartbrain* was shown to improve cognition in Alzheimer's patients in an adult day care facility in Spain. Hence, the increasing interest in using games for people with dementia. One the goal of the project is to develop a specific game for senior based on the requirements that are specific to people with dementia. Amongst the requirements, it is important to foster enjoyment while playing and provide functions tailoring the game to the level of the players. It is essential to create a game that enhances the communication within a community; therefore, several players could use the game not in a competitive more but rather as a social activity.


B. Game design Requirements

On order to collect data, we have used a qualitative approach. We have interviewed some people working at different level of a care elderly home environments such as nurses and leader and with some family members. In addition, one researcher has conducted its own observation of the behaviour of elderly people. In order to complete the data, an extension medical literature reviews have been performed. Analysis of the collected data leads us to define the following requirements

1. Short-term memory

It is recognized that elderly people with dementia lose their short term memory first and their long term memory last. Quite often they might forget the information they received few minutes ago or what they had for lunch time, but still they will remember people or events from their earlier years. This has a consequence, that patient during the play might easily forget instructions and information. Therefore, there is a need to recall the game situation and eventually repeat the information. In addition, it is important to provide information about the game in a slow manner with option to restart easily if the loss memory has occurred. Messages should short and concise and displayed on the screen. One interesting feature of the game would be that the system is able to detect the loss memory of the player by for instance the player's position / posture so that it can trigger a break in the game play and allow a restart of the movement.

2. Visual requirements

Literature review indicates that it is common to have low vision at the age of 70-75 years, and we can therefore conclude that this form of visual impairment is part of a natural aging process. The most common form for vision impairment is macular degeneration, cataract and glaucoma. The various symptoms range from acuity reduction, vision distortion, and color vision; and in some cases partial loss of the vision. Hence, people might experience some difficulties to read or interpret the body language. Therefore, as a requirement, the screen should be large enough and clear and should be positioned at readable distance. Additional, visual messages such as icons and illustrations must be simple and easily interpretable. For instance, the following symbol  means music. Furthermore, the user interface should be designed by taking into account the "color" feature. An estimated nine to twelve percent of the male population suffers from some form of color vision deficiency. Color blindness or color vision deficiency is the inability to perceive color differences under lighting conditions when color vision is not normally impaired. Therefore, while designing the graphical interface of the game, it is important to not rely on color alone to convey information but rather use black and white color or use colors that have a high degree of contrast with each other. The ultimate solution would be to avoid using color as a way to inform

3. Hearing requirement

Hearing impairment is very common among elderly people and can seriously affect their quality of life, personal safety, and ability to function independently [13]. Usually, the aptitude to hear high sounds goes leading to problems to hear bird or women's. The problem might even get worse when there is a background voice such as a game party. Therefore, the volume of the sound should be adequate. Audio message should be as short as possible.

4. Motion requirement

Seniors often experience joint pain, problems with mobility, and a lack of general flexibility. Therefore, it is important to understand their possible physical limitation in order to avoid injuries. Hence, the game should be designed with in mind several level of difficulties. Very basic and simple steps of the dance are possible. According to the confidence of the player,

there is a possibility to increase the number of steps, or the speed. It is crucial that the patient feel that it is quite safe to play. Other external parameter should be taken into account such as enough light in the room, environment setting and so forth.

5. Technological requirements

It is well known that older people have difficulty coping with new technology such as computers, internet, touch screen, modern interface and advanced mobile functions. Senior people are often reluctant to learn new piece of technology. Therefore, it is quite logical to use rather known devices or tools such as television, remote control, computer for some of them and so forth. Today with the advance of innovative such as Kinect, a whole range of possibilities are offered for the creation of game. The main advantages of Kinect technologies are to allow senior people to use their body movements to navigate through a selection of menu for instance. The game should be easier to use, with possibility to adjust the game's controls, features, and communication.

6. Fun Requirement

The enjoyment feeling to play might be different according to the age or the gender of the player. According to [9], elderly woman like to socialize while men still like competing with others or with themselves. Thus, it is important to implement score function for competition.

7. Feeling and Emotional requirement

In order to insure the success of the senior game dance or sport, it is crucial to make sure that people are enough motivated it to play it again and again. One aspect to consider is related to the perceived success that the player could feel. Studies highlight if senior fell that they will not be able to complete the game, they will feel unmotivated. Thus, it is important that the game offer levels that they can reach easily. In addition, the game should not expose openly their failure to others residents. In addition, staff should offer praise and encourage people to use the game as a social tool connecting the community. In addition, game system can be used as a tool in distraction therapy for pain and anxiety [14].

IV. DANCING GAME PROTOTYPE

Some part of the interface development will inspired by the work of [15]. The computer game is developed for Microsoft Xbox console connected to Kinect for input and a TV monitor for output. Xbox 360 Kinect is a controller free camera system using infrared technology. Kinect operates through Smart technology features such as gesture recognition, facial recognition and voice recognition [16]. Body movements is tracked at a frequency of 30Hz and given as 3D coordinates is used as inputs to the game. The software tracks 48 points of the body for as many as two players in real time. It offers full body mobility, the camera tilts up and down, and it follows the user around the room.

The computer game will be programmed in Microsoft XNA. This is dedicated tool for video game development and management. The key features are listed below

1. The game can be used by up to four players thus allowing competition between 2 couples.
2. Music synchronization tool that enables the user to choose their own dance music. This will be a simple way of changing the dance sport difficulty level, simply by selecting a song with a lover beat per minute will slow down the dance experience.
3. Possibility to watch their performances streaming live on the Television

When the player is ready, graphics appear on the screen to guide the dance step movements. At first, movements are slow, but progress in speed and complexity as the player becomes more skilled. The set-up - which allows for completely hands-free games and controlling the console with voice commands - is designed to appeal to elderly people.

V. CONCLUSION

With the aim to design a game system for enhancing cognitive and physical abilities of people, we have collected requirement based on interviews and literature reviews. Most of the requirements have been translated into technical specification that will be implemented in a dance/sport game prototype. The project is still under development; however the preliminary results are already promising. Hence, there is still a need to improve the requirements elicitation of the game based on an assessment. Preliminary assessment could be done with patient using traditional games. The results will contribute to refine the defined requirements. After game development, one important step of this project is to conduct a large scale assessment in order to validate research claiming that game can represent a powerful too enhancing the cognitive and physical abilities of elderly people. However, based on our data, we can already state that the combination of conventional or computer games associate with physical activities and medications can provide to the patient the best level of stimulating cognitive and physical activities.

REFERENCES

- [1] A. Ardichvili, V. Page, and T. Wentling, "Motivation and Barriers to Participation in Virtual Knowledge-Sharing Communities of Practice," in OKLC, Athens, Greece, 2002.
- [2] Leah K Moynihan and M. John F Dashe. (2008, september 2008). Patient information: Stroke symptoms and diagnosis. Available: <http://www.uptodate.com/patients/content/topic.do?topicKey=-60z0Ko4oBLhUD1>
- [3] H. Zhou and H. Hu, "A Survey - Human Movement Tracking and Stroke Rehabilitation," University of Essex, United Kingdom, Report October 2011 2004.
- [4] E. Lawrence, C. Sax, K. F. Navarro, and M. Qiao, "Interactive Games to Improve Quality of Life for the Elderly: Towards Integration into a WSN Monitoring System," presented at the Proceedings of the 2010 Second International Conference on eHealth, Telemedicine, and Social Medicine, 2010.
- [5] S. Flynn, P. Palma, and A. Bender. (2007, October 2011). Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: A case report. *Journal of Neurologic Physical Therapy* 31(4), 180-189. Available:

- http://journals.lww.com/jnpt/Fulltext/2007/12000/Feasibility_of_Using_the_Sony_PlayStation_2_Gaming.5.aspx
- [6] Graves L, Stratton G, Ridgers ND, and C. NT. (2007, Comparison of energy expenditure in adolescents when playing new generation and sedentary computer games: cross sectional study. *BMJ Publishing Group* (335(7633):), 1282-1284. Available: <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2151174/>
- [7] D. Graf, L. Pratt, C. Hester, and K. Short, "Playing active video games increases energy expenditure in children," *Pediatrics*, vol. 124, pp. 534–540, 2009.
- [8] M. R. Foley L, "Use of active video games to increase physical activity in children: a (virtual) reality?," *Pediatrics*, vol. 22, pp. 7-20., 2010.
- [9] K. Ogomori, M. Nagamachi, K. Ishihara, S. Ishihara, and M. Kohchi, "Requirements for a Cognitive Training Game for Elderly or Disabled People," in *Biometrics and Kansei Engineering (ICBAKE)*, 2011 International Conference on, 2011, pp. 150-154.
- [10] Bartolome, x, N. A., A. M. Zorrilla, and B. G. Zapirain, "A serious game to improve human relationships in patients with neuropsychological disorders," in *Games Innovations Conference (ICE-GIC)*, 2010 International IEEE Consumer Electronics Society's, 2010, pp. 1-5.
- [11] T. Shubert, "The use of commercial health video games to promote physical activity in older adults," *Annals of {Long-Term} Care*, vol. 18, pp. 27-32, 2010.
- [12] B. P. Sobel, "Bingo vs. physical intervention in stimulating short-term cognition in Alzheimer's disease patients " *American Journal of Alzheimer's Disease and Other Dementias* ., vol. 16, pp. 115-120, 2001.
- [13] US CongressOffice of Technology Assessment, "Hearing Impairment and Elderly People, A Background Paper," OTA-BP-BA-30, Washington1986.
- [14] C. Watters, S. Oore, M. Shepherd, A. Abouzied, A. Cox, M. Kellar, H. Kharrazi, F. Liu, and A. Otley, "Extending the Use of Games in Health Care," in *Proceedings of the 39th Hawaii International Conference on System Sciences Hawaii* 2006.
- [15] Morandell, M. M., A. Hochgatterer, et al. (2008). Avatars in Assistive Homes for the Elderly. *Proceedings of the 4th Symposium of the Workgroup Human-Computer Interaction and Usability Engineering of the Austrian Computer Society on HCI and Usability for Education and Work*. Graz, Austria, Springer-Verlag: 391-402.
- [16] Depriest, D. and K. Barilovits (2011). LIVE: Xbox Kinect© s Virtual Realities to Learning Games. 16th ANNUAL TCC Worldwide Online Conference, Hawa