Survey on Serious Game for Elderly

Shuji Hao[*] and Chunyan Miao[+]

* Institute of High Performance Computing Agency for
Science Technology and Research (A*STAR), Singapore
+Joint NTU-UBC Research Centre of Excellence in
Active Living for the Elderly (LILY), Nanyang
Technological University, Singapore

haosj@ihpc.a-star.edu.sg, ascymiao@ntu.edu.sg

Abstract

With the growing and aging population, health deterioration has also been on the rise especially in elderly group. This would then impact the daily living of one. Thus there is a need to look into how than can technology aid elderly in living apart from having to burden family members. In this research, we will want to look into classifying serious games and to find out what are the key principles needed to be designed for elderly.

There two main objectives of this survey. Firstly it is to understand how the serious gaming can help elderly to improve their life also aiding them to regain cognitive functions which was impaired by certain diseases or deterioration due to age. Secondly to suggest a Taxonomy of Serious Game for Elderly in order to dismiss any myth or misconception about the characteristics of such games so that they can deliver the result effectively to elderly.

Keyword: Elderly, serious games, HCI, human factor.

1. INTRODUCTION

Along with the game development and advance in computer graphics hardware, serious games have become a significant research area. Practical applications for the use of serious games encompass many areas, from motion assessing and recovery, to cognitive evaluation and enhancement. For example, in the aspect of motor recovery, Microsoft Kinect system can detect and model human gestures without the need to hold any sensors. (Lange et al., 2012, Alvarez and Grogan, 2012).

With the era of ageing population, the needs of enhancing active living for the elderly are increasing as the result of illness such as Stroke and Parkinson (Betker, 2010). These illnesses are two of the most common causes of death and disability of elderly, and usually those who have survived would suffer from the impairment of motor, and cognitive abilities, which severely impact the performance of active living such as wearing clothes, walking alone and others (Ma, 2010).

The serious games are defined as the games designed for a primary purpose other than pure entertainment (Rego et al., 2010), and they have been widely recognized as a great promise to address those challenges(Laver et al., 2011). As the most important part of serious games for elderly, various rehabilitation game systems (RGS) have been developed for stroke patients. RGS, combining the task specific training scenarios and engaging game mechanism, performed positive effect on motor recovery (Levin, 2011), balance training (Rendon, 2012) and cognitive rehabilitation (Cherniack, 2011). The development of cheap equipments and the unsupervised RGS also make the home-based therapy feasible, which would significantly reduce the burdens for the families and society (Alankus, 2012).

2. LITERATURE REVIEW

In recent years, different types of serious games were developed for the elderly. However the designs tend to be task-dependent and the interaction technologies between the players and games are also diverse, which make it very difficult to compare and find out commonality. Another motivation here is trying to figure out the key dimensions of serious games when developing for and with the elderly.

The work in (Rego et al., 2010) is very close to our article. The author firstly reviewed the serious games and the rehabilitation games, and then developed a taxonomy based on application area and gameplay, which were used to classify the serious rehabilitation games into ten categories. However, two application areas (Motor and Cognition) of the first category are too inclusive to compare among different games. For example, most of the games will only focus on one specific motor aspect such as upper limb, lower limb, or balance.

Another similar review is the one developed by (Holden, 2005), in which, the author mainly focused on the motor rehabilitation virtual environments. Firstly, available equipment and rationale were discussed. Secondly, also the main part, several Virtual Reality systems were described from different aspects such as results of clinical studies, and areas covered (Stroke, Parkinson, Acquired Brain Injury and so on). Prior to this survey is factors such as cognition rehabilitation, the game play and the game structure are being reviewed also.

In summary, previous works mostly focus on evaluating the rationale or a specific area of the serious games for elderly (Hendricks et al., 2002, Laver et al., 2012, Lewis and Rosie, 2012, Yeh and Adviser-Sawchuk, 2008, Henderson et al., 2007, Levin, 2011, Lucca, 2009, Rahman and Shaheen, 2011, Tsirlin et al., 2009). Obviously, only few dimensions were covered and not complete to describe the serious games for the elderly considering the different applications areas and the distinguished interactions features the elderly have.

The rest of the paper is organized as follows. To classify the serious games for the elderly with multi-dimension by combining the specific application areas and games features, in the second section, we will illustrate our material collection and classification method. A discussion of the classification method and limitation will be presented in section three. Section four gives a conclusion of our work.

3. DATA COLLECTION AND CLASSIFICATION

We firstly illustrate the criteria and search strategy when collecting data, and then the details about classification method and the dimensions identified.

3.1 Data Collection

3.1.1   Inclusion/exclusion criteria

The first criterion is that the target people of the serious games must be elderly, with the age from 62 onward (Singapore recommended retirement age). Secondly, serious games should aim to enhance or recover cognition and motion abilities. The games could be accompanied with hardware, for example, the robot-based virtual reality application containing the incentive motivation, but the applications only including hardware were excluded.

3.1.2   Search strategy

In searching related researches, we used the following databases: ACM Digital Library, IEEE Electronic Library, SpringerLink, ProQuest Dissertations and Thesis, Engineering Village, SciVerse ScienceDirect, Web of Science, PubMed. The key words we used for searching are: elderly, games, rehabilitation, Stroke, Parkinson, cognition, and balance. To get relative publications as many as possible, firstly retrieve with the wide-scope words, for example, elderly and game, and then narrow down the scope within the results. Lastly, authors independently reviewed the title and abstracts to determine whether they fulfill the predefined inclusion criteria.

3.2 Classification Dimensions

Firstly, three of the reviewers independently reviewed the previous literature on serious games for the elderly to gather the dimensions and values. Secondly, all of the dimensions are discussed to be classified, and duplicated dimensions are removed. At last, three categories: Cognitive, gameplay, and game structure, are extracted from the 21 dimensions. Based on these dimensions, several existing games are reviewed and compared.

3.2.1   Cognitive

●   Motor: This dimension describes the main goals of the serious games: assessment and recovery of the motion ability. And these goals are usually crucial and proved feasible to make the elderly live independently after strokes and other brain injuries.

Four motion related types are extracted from (Cameirao et al., 2009, Hendricks et al., 2002, Henderson et al., 2007, Holden, 2005): upper and lower limb recovery, balance training, and compensatory motion reducing, and latest games about motion ability evaluation and recovery are reviewed.

Upper and lower extremity disability usually happens to one side of the body with the stroke patients, which are usually recoverable and improvable via a repetitive and tasks-oriented movement.

Yeh developed a serial VR tasks by integrating various motor patterns and the therapists' rehabilitation goals (Yeh and Adviser-Sawchuk, 2008), by which the patients could practice the isolated finger movement,coordinated wrist and forearm movement, coordinated thumb and index movement, coordinated arm and shoulder movement.

Several games developed by Alankus are targeting the upper extremity recovery: Frog Simon, Dirt Race, Baseball Catch, Catch the Kitty and so on (Alankus et al., 2010).

Cameirao (Cameirao et al., 2009) developed a Rehabilitation Gaming System (RGS) for the upper extremities of stroke patients. The author also conducted the research to evaluate the usability and the acceptance of the RGS which resulted in highly positive effect (Cameirao et al., 2010, 2012).

●   Attention: The ability to concentrate on a particular object or situation, action or thought for at least a substantial amount of time. Both video and computer games can be complex and flexible activities that use multiple cognitive abilities, which offer motivational rewards and also be socially involved. Games is able to improve younger adults cognitive abilities in areas such as visual attention ([Feng et al., 2007], [Green and Bavelier, 2003],

[Green et al., 2010]) and mental rotation ability ([De Lisi and Cammarano, 1996], [Feng et al., 2007], [Okagaki and Frensch, 1994] and [Terlecki et al., 2008]).

Video games have also shown the capability to improve older adults' cognitive abilities. A study demonstrated that the use of a real-time strategy game called Rise of Nations in a cognitive training program for older adults (Basak et al., 2008). The player in this game is required to gather resources, research technologies, and build and control large armies all in the stage of real time. Result has suggested that the experimental group of older adults have significant improvements in task switching, working memory, visual short-term memory and reasoning when compared to the control group (Basak et al., 2008).

● Memory: Memory is an ability that involves complex processes such as the storage and retrieval (Nunes, et al., 2010). The types of memory are working memory, long-term memory (permanent storage of information), semantic memory (Storing factual information), and prospective memory (characterized by remembering). In game play, working memory plays a crucial role as it is capable to keep information active temporarily and supports human thought processes by providing an interface between perceptions, long-term and action (Baumeister, et al., 2010). With decline of age, elderly will have working memory issue. For example, elderly will find it difficult to remember the previous screen or interface in game play. By providing a simplicity and intuitiveness interface, this will keep cognitive and memory processing to a minimum for the elderly (Nunes, et al., 2010).

● Language and Auditory Processing: Elderly are likely to develop age related conditions. One of it will be declines in auditory acuity. A young adult can normally hear sound frequencies up to 15000 vibrations per second and elderly will not be unable to hear the sound vibrations if it is greater than 4000 vibrations (Nunes, et al., 2010). Elderly will find it hard to understand synthetic speech as it is often distorted (Ijsselsteijn, et al., 2007). However, elderly will find it easier to hear a lower frequency tones compare to higher

pitched sounds. To design a game which is able to fit elderly hearing function, it would be helpful to include sound effect with tactile feedback through a rumble pad or force-feedback joystick (Ijsselsteijn, et al., 2007). For online social play, headsets and text messaging for communication is recommended.

● Visual and Spatial Processing: Another age related conditions for elderly is change in vision. It can be affected with multiple ways such as visual acuity, peripheral vision, presbyopia and dark adaptation (Nunes, et al., 2010). Elderly will have problem to read small print instructions or captions, and to locate information on the screen (Ijsselsteijn, et al., 2007). Elderly will miss out some of the details from poorly illuminated game play environment and to address this issue, it should allow user to control the font, contrast setting and the color. Allow to zoom, resize the window, and a single click to undo the adjustment (Ijsselsteijn, et al., 2007).

3.2.2   Gameplay

● Adaptive Difficulty: Adaptive difficulty of the games are promising to the progressive recovery or enhancement of the motion and cognition, especially for the home-based rehabilitation games. Several variables are imported by considering the specific target: the scene themes, models size, friction, limb range to achieve the job. In the "Pinch Test" game developed by (Yeh and Adviser-Sawchuk, 2008),the researcher adopted six parameters to adjust the difficulty levels. For example, it would become difficult to grasp the model by decrease the size of the cubic, and in turn the game could train the coordinated thumb and index movement with higher difficulty, in which the player could make much more progress. The RGS in (Cameirao et al., 2010) introduced several parameters to adjust the difficulty online: speed of the moving objects, the interval between the appearance of the consecutive objects, and the range of the dispersion of the models.

● Social Interaction: Being retired to elderly is many times associated with a loss of social importance and power due to the disengagement of an active social role (Vasconcelos, et al., 2012). This will incite identity crisis with a loss of self-esteem. One of the most important aspects of well-being to elderly is social contact. However, various factors such as personal vulnerability, contextual obstacles and environment, psychological conflict and stress are the hinder for elderly (Vasconcelos, et al., 2012). Elderly might have intergenerational issue such as communication between the young who feel patronized, overly nurturing and yet convey unfavorable stereotypes about their peer group (Theng, Chua et al. 2012). Considering the above-mentioned problems for elderly, game play is able to address some of these issues. For example, although not all family and friends are interested in game playing but elderly will have more time spent together where one is watching the television and the other is playing. Moreover, social interaction is offered by structuring the conversation with family and friends and even meeting new people (Schutter & Abeele, 2010). Some studies show that elderly benefit from intergenerational programs and they look forward to these programs (Theng, Chua et al. 2012).

● Engaging: Engagement is related to motivation, achievement, and task persistence (Hoffman & Nadelson, 2010). In studies on well-being, engagement has also been described as an optimal state of mind; called Flow, in which people experience a sense of enjoyment by losing the sense of self and time (Rozendaal, et al., 2009). To create engagement in game play, both richness (excitement experienced) and control (confidence experienced) need to be optimized (Rozendaal, et al., 2009). A lack of either one will result in boredom and decrease of anxiety. With increase of game features, functions, degrees of freedom, amounts of visual forms, colors and sound effects vividness, the level of experienced richness will increase. And with the increase of game features and functions, players can experience control by choosing which goal to pursue.

In game play for elderly, it is important to gain sense of control as soon as the game start as elderly may find decision making more challenging due to cognitive impairments (Vasconcelos, et al., 2012). Provide positive feedback rather than negative feedback as this will keep the elderly engaged. It should allow player to quickly reach proficiency as elderly are less likely to learn via trial and error. Lastly, elderly do not want to spend time on unknown activities and game should not be time consuming (Vasconcelos, et al., 2012).

●   Immersive: It is the state of consciousness where an individual is aware of his physical self who is surrounded and engrossed in an artificial environment which created a perception of presence in a non-physical world (Schrader & Bastiaens, 2012).

●   Motivation: How people are motivated in the game is influenced by both personal and situational factors (Bostan, 2009). The personal factors consist of three fundamental human needs which are autonomy, competence, and relatedness (Peng, et al., 2012). People will feel motivated where they have the power to make their choices (autonomy), able to perform the behavior effectively (competence) and authentic social connection with others (relatedness) (Bostan, 2009).In game, autonomy refers to how much choice players are given for customization within the game domain. Competence refers to dynamic adjustment of difficulty of the challenges in the game and relatedness focuses the feeling of being involved with others in the social environment (Peng, et al., 2012).

Beside of the personal factors, situational factors are another key point to motivate people in game. It provides recognition, rewards and goals achievement. The goals achievement consists of short-term and long-term goals. The difference is the immediate achievement rewards and overall reward structure of the game (Bostan, 2009). For example, supply users with a score system and let them keep track and compare their progress (Vasconcelos, et al., 2012). Therefore, it is important to look into these two factors to understand the motivation in game.

● 	Biofeedback: It is the process of gaining knowledge of physiological responses with the aid of instruments. These instruments are hardware devices measure and display physiological variables such as skin conductivity and heart rate inconsistency, so that allow the user to learn to self-regulate the achieve reliability effects. It is important to look into methods that offer a more efficient solution to how aesthetic meaning arises through this cognitive-based information. The understanding of how audio-visual media, and beyond, which would trigger valuable cognitive responses of the user through psychophysical affection (Lang 1994; Mandryk and Stella 2006). Research has also been suggested that electromagnetic might be a useful for exploring affections and their impact on a person's cognitive system. Therefore, a different type of devices which produce a spectrum of electromagnetic frequencies in the form of sound, visual vibration, radiations, mechanical vibrations including visualization systems which can be interpreted as meaningful changes in an individual's consciousness. This cognitive effects can describe the participant's cognition instantly, as a response to his or her interaction with the system, with the aim to simulate the successful affective responses pertaining to the gaming objective. (Zics, 2011)

● 	Problem solving: It is defined as a higher-order cognitive process which requires the variation and regulating of more routine skills. It can be achieve by introducing complex natural tasks as problem case which have been the most effective in demonstrating knowledge transfer beyond the specific tasks trained (Green, Li, & Bavelier, 2010).

3.2.3   Game Structure

● 	Flexibility: One of the issues that elderly face is the motor skills especially when trying to interact with computer systems. These include loss of flexibility and variability in movement.(Vasconcelos, et al., 2012). Motion-based games such as playing Nintendo Wii or Microsoft Kinect could potentially become an alternative way to improve the overall physical well-being of elderly (Kickmeier-Rust, et al., 2012). This might include being able to

perform number of knee bends or arm circles in gameplay. However, knowing the elderly mobility limitations is important. By selecting the right activities for their level, the elderly will able to enjoy physically in gameplay (Kickmeier-Rust, et al., 2012).

● 　　Clinical Validity: This dimension describes the evaluation of the serious games, and whether the article provide any proof or evidence to support the uses of the games. Alankus carried out a longitude home-based exploration of the upper limb recovery games (Alankus et al., 2011), in which,a 62 year old woman with seventeen years post-stroke played the games for approximately one hour a day, five days a week. The results of the study showed the motor ability recovered significantly within six weeks.

Most of the research were focusing on studying validity of games as a whole (Holden, 2005, Henderson et al., 2007, Laver et al., 2012, Rahman and Shaheen, 2011), and few of them have investigated the impact of different aspects of the games system. To address this issue,Cameirao developed three different interface technologies: vision-base tracking, haptics, anda passive exoskeleton (Cameirao et al., 2012). Forty-four stroke patients were invited to use one of the configuration randomly. The results not only revealed significant improvements for all groups, but also tell the different beneficial effects of three interfaces.

● 　　Customizable: Individual games are motivating to make a much more progress. This dimension describes whether the games have considered different players' tastes, motion and cognitive ability. Social context, type of motion required, and cognitive challenge are identified and integrated to the games developed (Alankus, 2012) such as Under the Sea, Pong, Frogger and Helicopters games.

The game system developed in (Cameirao et al., 2010) presented to be able to the dynamically adjust difficulty by firstly capturing specific features of each patient's movement. This features also made the games a promise of being set at home.

●   Portability: Training usually needs a highly repetitive and daily exercise, which often becomes impossible for an ordinary family to gain therapists' professional supervision by considering the time and cost. So if the players could train on his own at home, it will be very important to the recovery and reduce the family workload.

In order to overcome the practical challenges of home-based rehabilitation, Yeh etc integrated webcam and wireless connectivity into the VR system, which brought the promise of the low-cost and fidelity of the systems used at home(Shih-Ching Yeh, 2007, Shih-Ching et al., 2007). Based on the affordable device Nintendo Wii remote and webcam, three games, the Helicopter, Pong, and Baseball Catch were setup at home for the patients (Alankus and Kelleher, 2012)

●   Assessment: The ability to track user's progression through each stage and display in an easy-to-read format. If required these data is able to transmitted to some professional or doctors to understand the user further. It is suggested by research (Bedek, Seitlinger, Kopeinik, & Albert, 2012) that such data should be capture within the game scenario which causes a medium level of stimulation most likely for motivating and emotionally appealing. Therefore a game structure should adapt to the user`s current competence, motivational or emotional state if necessary. With consistent reviewing assessment on the user usage of the game, it will motivate the users and simulate speedy recovery.

●   Simulation and Interactivity: This refers to a type of genre describing games which represent a simulated environment. These games allow the interactions between the playable characters and the environment realistically. These kinds of games are usually more complex in terms of gameplay. Research (Vogel, 2006) had suggested that those using interactive simulations or games report higher cognitive gains and better attitudes toward learning compared to those using traditional teaching methods.

4. DISCUSSION

Based on recent studies, it is stated that the aged population is dramatically increasing in both developing and developed countries (Marin, Navarro, & Lawrence, 2011). In this paper, we discuss about age-related sensory, motor properties and cognitive. These will influence the elderly's experience of interacting with digital games. Most of the games designed focus on interfaces, interactive application, and usability to elderly (Ijsselsteijn, et al., 2007). However, usability is not sufficient to motivate elderly in game play and we need to investigate the motivations to engage the elderly in game play.

It is a challenge to motivate and engage Elderly in game play. To understand the context of game play by elderly, we created the codebook to categorize application area based on age related conditions of elderly. We looked into the structure of gameplay and suggest the features and functions in designing game for elderly.

A few literature reviews and categorization of relevant works had already looked into the context and feasibility of game play for elderly and these studies often used therapeutic and motion based game such as Nintendo Wii Fit. We would like to look into area like gesture interaction in game play for elderly. For example, elderly will find it difficult in dragging elements if the elderly suffer from motor skill decline.

Future works can look into how the elderly interact using tablet in game play as the users will tend to press on the button for longer and necessary and the type of settings or configurations in the game. Rethinking elderly game playing from a gender perspective will be interesting.

5. CONCLUSION

By understanding varies serious games available in the market we have derived a typology which is able to categorize the games that can be consider as "Serious Game for elderly". Games which have such qualities of any type that satisfied one more conditions in the proposed categories of Cognitive,

Game Play and Game Structure (refer to APPENDIX A) would have high possibilities of delivered the objectives of the serious gaming for elderly.

The derived typology can also serve as a referencing tools for designers and developers who are interested in developing serious games in the elderly domain. This information allow an overview of features and characteristics of such games or apps belong in this domain. This study should not only benefits consumer but also health care practitioner, game developer and even researchers who may want to discover alternative applications in this area.

This classification of this paper is obtained through comparative analysis of existing serious games available in the market and in the literature. Therefore an in-depth research is needed to further validate the accuracy of this typology. All the types in this typology are derived from current technologies available in gaming domain which may be useful until a next breakthrough in technology for such domain.

The result of such games may vary from individual therefore further conclusive clinical studies are required to be used as mainstream in treatment or rehabilitation.

6. ACKNOWLEDGMENTS

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Appendix A

Table 1 Classification of Serious Games for Elderly

Category	Dimension	Description	Samples
Cognitive	Motor	Whether the game is developed for elderly with stroke and other brain injury illness to recover motor ability.	RGS (Cameirao, 2009), Penguin Racer (Yeh, 2008)
	Attention	Improve Substantial Concentration.	Play Attention (Prescott, 2005)
	Memory	Whether the system could be intelligent enough to learn the profile of this user and continue where he left from?	Brain Age (McDougall & House, 2012)
	Language and Auditory processing	How does elderly differentiate and comprehend sounds and generate verbal output. This is important to design a game which able to fit elderly hearing functions.	Simon Memory game (Humes & Floyd, 2005)
	Visual and Spatial processing	To understand how elder process visual effects like graphics and how they process.	Simon Memory game (Humes & Floyd, 2005)
	Adaptive Difficulty	Whether the games could adaptively adjust difficulty.	Gold Searching (Yeh and Adviser-Sawchuk, 2008)
	Social Interaction	Allow users to interact to each other and also improve moral support and knowledge sharing.	TableTalk Poker (Shim, Baecker, Birnholtz, & Moffatt, 2010), Walk 2 Win (Mubin, Shahid, &

Gameplay			Mahmud, 2008)
	Engaging	To understand what type of interaction/ interface design to engage the elder	Walk 2 Win (Mubin, Shahid, & Mahmud, 2008)
	Immersive	This should be content focus and a bit entertaining will find out more.	Minecraft (Short, 2012)
	Motivation	What type of rewards will encourage elder. What types of scoring system, interactive game play involve more than one player?	Walk 2 Win (Mubin, Shahid, & Mahmud, 2008)
	Biofeedback	How the electromagnetic frequencies response provide valuable information in designing a serious game for elderly.	Wild Divine (Amon & Campbell, 2008)
	Problem solving	The tasks or steps taken for elderly to complete a simply task.	Brain Age (McDougall & House, 2012)
Game Structure	Flexibility	Does the game require certain flex action to play?	Dance Dance Revolution (Smith, Sherrington, Studenski, Schoene, & Lord, 2011)
	Clinical Validation	Any proof or evidence to justify.	Frog Simon (Alankus, 2010)
	Customizable	Whether the games have considered different players' tastes, motion and cognitive ability.	Spheroids (Cameirao et al., 2010)
	Portability	Whether the training could be conducted by the users own.	Pong (Shih-Ching Yeh, 2007)
	Assessment	How do the data being assessed and interpreted into meaningful information to users and professionals.	Brain Age (McDougall & House, 2012)
	Simulation & Interactivity	How simulation with interactivities affect the overall result of such games.	Minecraft (Short, 2012)

Shuji Hao Shuji Hao is a Scientist in the Institute of High Performance Computing (IHPC), Agency for Science Technology and Research (A*STAR), Singapore. Prior to joining IHPC, he finished PhD in Nanyang Technological University (NTU) in 2016. During his PhD study, he has been dedicated to designing large-scale sustainable machine learning algorithms.

Dr Chunyan Miao is currently serves as Professor as well as the Director of Joint NTU-UBC Research Centre of Excellence in Active Living for the Elderly (LILY). She has been an Assistant Professor at Division of Information System, School of Computer Engineering (SCE), Nanyang Technological University (NTU) since 2003. Prior to joining NTU, she was an Instructor and Postdoctoral Fellow at