



International Journal of Control Theory and Applications

ISSN : 0974-5572

© International Science Press

Volume 9 • Number 44 • 2016

Challenge of Existing Game in Rehabilitation

Siti Hazyanti Binti Mohd Hashim^a and Marina Binti Ismail^b

^{a,b}Faculty of Computer and Mathematical sciences, Faculty of Computer and Mathematical sciences, Universiti Teknologi MARA (UiTM), 40450 Shah Alam, Selangor, Malaysia. Email: ^ahazyanti_91@yahoo.com; ^bmarina@tmsk.uitm.edu.my

Abstract: The game is a structured form of play, usually for enjoyment and sometime for rehabilitation. In rehabilitation of stroke patient, there are many game that we can choose and become as a rehab therapy. The games is choose because of their interesting and fun to play. However, there are challenge of existing game that sometime not suitable to be use in rehabilitation. Dual cognitive task therapy is a combination of motor skill and cognitive task simultaneously. There is no game that is suitable for this dual task problem. It need a design of game that suitable for dual task and also suitable to be use for stroke patient. Therefore, this study aims to summarize the challenge of existing game in rehabilitation especially for dual cognitive task therapy. The expected result is about the need of new game in dual cognitive rehabilitation of stroke patient.

Keywords: Game, challenge of existing game, stroke patient.

1. INTRODUCTION

As we mention about game, actually game is an application that someone play through and sometime will become addicted. It is because of the impact of game which is very interesting, fun and happy when play.

Rehabilitation is normally done through trainings and more recently through games. A game engine company, The Intelligent Gaming Engine had introduced a rehab module games for stroke patient to play while performing rehabilitation exercises [1]. Rehab in game have shown some positive impact [2]. It has proven that patient with game rehab had faster progress than patient with conventional therapy [3].

Nowadays, there are a lot game that people playing. Among the game, there are game that can be used for rehab in some disease. However, there are challenge of this existing game that sometime not suitable to be use in rehabilitation especially for dual cognitive task rehab. Dual cognitive task need to combine two task motor skill and cognitive task simultaneously. This two task must be do together and these become difficult task that stroke patient do.

Therefore, this study aims to identify the challenge of existing game in rehabilitation and why we need to develop a new game for dual cognitive rehab. The expected result is the need of new game that can be use in rehabilitation.

2. STROKE PATIENT

Stroke is a major cause of adult disability in developed countries and it totals about 16 million new first stroke events per year. Given such increasing figures, the cost of stroke rehabilitation is expected to saturate National Health Service Providers which are expected to be forced to shorten the duration of the rehabilitation support. However, exercising should be continued also outside the hospital to avoid losing the benefits of hospital rehabilitation and to stabilize psychophysical conditions.

3. DUAL COGNITIVE TASK FOR STROKE PATIENT

Dual cognitive task is a motor and cognitive task that we do simultaneously. Its normal for healthy people but for stroke patient, dual cognitive task is difficult task. They need special design of game that suitable for them to do rehab. Currently, dual cognitive rehab are using conventional training. Many patient feels boring and uninterested to do their training.

Dual cognitive task for example walking and talking.

The important thing in real life is the ability to perform dual cognitive task simultaneously [4]. Due to the loss of physical ability under dual-task conditions most stroke patients face to fall [5][6][7][8]. The relationship between cognition and motor control after brain impaired decrease due to factors which stroke patient has significant implications for understanding the recovery of motor function [9].

Dual cognitive task is performing two cognitive related tasks simultaneously, for example walking and talking. Dual cognitive task is easy for a normal and healthy individual as walking becomes an automatic task [1] [2]. However, for a brain impaired individuals, such a stroke patient, doing the two cognitive-demand tasks is a challenging task. Walking while performing another task for example talking is challenging for many stroke survivors [3]. Patients with stroke have a number of physical impairments, including movement, cognitive, sensory, language, and visual disorders. Among them, movement disorders can limit muscle control and motion functions or mobility, as well as a decrease in balance control abilities [4].

Cognitive function refers to the ability to understand the things that occur in daily life. The cognitive domain includes the abilities of concentration, memory, planning, systematization, problem solving, abstraction, and use of language. Cognitive processing is important for motor control because of movements cannot be performed without intention. Stroke patients with decreased cognitive ability cannot adequately utilize the cognitive function needed for motor learning [5].

Cognitive-motor interference (CMI) is evident when dual tasking of cognitive task and a motor task results in decreasing in performance, relate to performance of each task separately [6]. Stroke patients usually exhibit inefficient walking because of decreased dynamic balance ability, decreased musculoskeletal and cardiovascular function. Compared with healthy persons, stroke patients have lower walking speeds and shorter duration of walking. Their daily functions are also limited and they cannot complete certain simultaneous tasks, such as conversing while walking [5].

Dual task performance is often requested in daily life activities, such as during walking while answering a phone call. In older adults, a dual task increases risk of fall [7]. More recently, researcher investigated the effects of the addition of different cognitive tasks on walking at slow or preferred speed, and found that the degree of decline in walking speed in dual-task condition was dependent on the nature of the cognitive task. Impairment in dual-task mobility has also been implicated in falls in the elderly population. The usefulness of dual-task assessment in identifying fallers among individuals with stroke has also been examined in a few studies, with mixed results [8]. The motor performance impairments observed during performance of a dual

task may result of decreased activity of information processing areas, most likely due to descendent of attention processes.

Many people after having a stroke have difficulty moving, thinking and sensing. This often results in problems with everyday activities such as writing, walking and driving. Virtual reality and interactive video gaming are new types of therapy being provided to people after having a stroke. The therapy involves using computer-based programs that are designed to simulate real life objects and events. Virtual reality and interactive video gaming may have some advantages over traditional therapy approaches as they can give people an opportunity to practice everyday activities that are not or cannot be practiced within the hospital environment. Furthermore, there are features of virtual reality that might mean that patients spend more time in therapy for example, the activity might be more motivating [9].

In the past couple of years, there has been an increase of game device use for areas other than actual gaming. The newest area of use is for physical health. Medical researchers and physical therapists are finding that using virtual reality games are very helpful in terms of treatment and rehabilitation for stroke patients [10]. Virtual reality (VR) has emerged as one of the most effective treatment in stroke therapy rehabilitation. This method is beneficial because it provide the patient and physical therapist with the opportunity to practice activities that are cannot be achieved within the clinical environment. Additionally, virtual reality is often designed to be more engaging, more interesting and more enjoyable than traditional stroke rehabilitation.

4. GAME AND REHABILITATION

The game is a structured form of play, usually for enjoyment and sometime for rehabilitation [11]. It also called a system in a computer-generated that is introduced by instruction to the player [10]. Since the beginning, games have been a tool to experiment with human. When we think about game, no other medium allows us to interact with like games do [12].

In rehabilitations, video games have been shown to have positive impacts [2]. The games are simple enough that any age group can play with, while fun enough that patients will forget they are undergoing physiotherapy exercises [13]. Physiotherapists have said that the immediate feedback of game encouraged patients to concentrate more and stay engaged with their rehabilitation [14].

Special attention to the main purpose of game is the positive feeling or impact the player gets for their life while playing the game. In the elderly, video game is one type of cognitive training and this has been support with some previous studies [15].

Besides, it also has been stated that when compared to traditional therapy, the use of games and exercises can help improve balance, strength, and speed. It would seem that in patient recovery, video games really benefit to them [16]. According to Bullinger, game become enjoyable activity which interact people to joins and match others player to measure the objective has been reach [17]. When playing game, people should not fear if they doing mistake because it is not in real world. A game is actually impress player to play to the next level continuously and make them addicted to that game. Therefore, this can be conclude that games are very useful as a rehab tool [18]. Games give many benefit and improvement to the patient physically and cognitively.

Playing video games has been shown to have many positive behavioral and physiological effects. In rehabilitations, video games have been shown to have positive impacts on cognitive performance, motor performance, and affect [3].

The review evidence for the potential use of video games in rehabilitation with respect to the behavioral, physiological, and motivational effects of gameplay. In this article, they offer a method to evaluate effects of video game play on motor learning and their potential to increase patient engagement with therapy, particularly

commercial games that can be interfaced with adapted control systems. They take the approach of integrating research across game design, motor learning, neurophysiology changes, and rehabilitation science to provide criteria by which therapists can assist patients in choosing games appropriate for rehabilitation. Researcher suggests that video games are beneficial for cognitive and motor skill learning in both rehabilitation science and experimental [4].

Video game play could be an effective supplement to traditional therapy. Motion controllers can be used to practice rehabilitation-relevant movements, and well-designed game mechanics can augment patient engagement and motivation in rehabilitation. They recommend future research and development exploring rehabilitation-relevant motions to control games and increase time in therapy through gameplay [4].

5. EXISTING GAME CHALLENGING TO BE USE IN REHAB

Stroke patients often have difficulties coordinating their arms and hands. They need special training to teach the brain to control again the body movements. Of course it is not just any computer game that can help achieve this. Table 1 will show example of existing game that use in rehabilitation.

Video game training is one type of cognitive training in the elderly. Some previous studies showed that playing a video game could lead to improve some cognitive functions in the healthy elderly [8]. To exemplify, researcher has present two of these mini games Animal Feeder and Fruit Catcher, which highlight the flexibility of our approach and the monitoring and adaptation capabilities. The Animal Feeder mini game aims to train patients' balance by implementing a dual task. The exercise requires the patient to kneel in front of the display and to move the impaired arm to touch different targets, which are represented by three hungry cows that have to be fed. In this game, patient should wearing virtual reality glove to feed animals. However this game not using 3D glass in order to show 3D environment. Beside, this game is only focus to motor skill, not for dual cognitive task [9].

The Fruit Catcher game is built on two different exercises. For the first exercise, the patient is required to shift his or her upper body to the left and to the right side, while keeping the feet still on the ground. For the second exercise, the patient must move laterally inside the mini game. In the basic concept of Fruit Catcher, the player must catch fruits falling from the top of a tree. The player avatar stands below the tree with a virtual basket on its head and can move the body laterally to catch the fruits with the basket. The player's score increases when a fruit falls into the basket. The fruits fall from different heights and from different positions on the horizontal axis and at a different frequency [9]. However, this game is challenging that mostly focus to motor skill not for dual cognitive task. The use of virtual basket in order to fruit catching. Stroke patient cannot hold heavy object in their hand. This game only depend on time, for example in one minutes, how much fruit patient able to catch. If the patient pass the fruit, nothing happened, they can follow on the game until one minute. There is no over game inside the game.

Kinect is sometime used in rehab, but Kinect is unable to discern between supination and pronation of the upper limbs. Players may not reach a sufficient rate of intensity to acquire efficient improvements. The game score is not correspond to motor recovery [20] [21]. It is important to note that the Wii may not be suitable for all patient populations some disadvantages include patients may require assistance and supervision while using the Wii. In Wii game, players imitate the motions required in various sports for example playing golf, tennis and baseball. In Kinect game the difficulty is when patient must react quickly to new leaks. Speed increases with player success. Compared to the Kinect and Wii sports does not have the same level of sensitivity, therefore it will not be as good at gathering data on movement. While the Wii sports is important for improving gross movements of the upper limb. Nintendo game is example of Wii sport game which is use Wii remote in order to play the game.

Table 1
Example of existing game that challenging in rehabilitation

Game system	Type of game	Description	Body part target	Challenge in virtual reality	Challenges	Challenge in game
Fruit catcher	VR game	The player must catch fruits falling from the top of tree.	Upper body to the left and to the right side	Use virtual basket in fruit catching. Stroke patient cannot hold something heavy in their hand.	Stroke	This game only depend on time, one minutes, how much fruit, and patient able to catch. If the patient pass the fruit, nothing happened, they can follow on the game until one minute.
Wii sports Nintendo	Wii game	The player must navigate the balloon through a series of obstacles by shifting their weight on the balance board in the direction they want the balloon to move.	Body balancing	This game need a Wii balance board. Board have it disadvantage when the patient need to stand up on it. Stroke patient difficult while standing because easy to fall.	Balance	High level of noise. Game feedback is not patient friendly
Circus challenge	Kinect game	It is often a challenge to retrain the brain to control a weakened limb after a stroke.	Motor skills	Use virtual reality controller. Instead of holding a controller, uses gloves not only bring patient hands, but also patient fingers into the virtual world.	Stroke patient cannot hold the Wii remote.	Sometime, the tasks in game are very difficult for stroke patient to play as they need to push their motor skill in doing task.
Animal feeder	VR game	Train patients' balance by implementing a dual task. The exercise requires the patient to kneel in front of the display and to move the impaired arm to touch different targets, which are represented by three hungry cows that have to be fed.	One arm	Wearing virtual reality glove to feed animals. This game not using 3D glass.	Stroke	This game is only focus to motor skill, not for dual cognitive task.
Fruit ninja	Mobil game	Use knife to cut the fruit which is using finger swipes	One arm	Use finger to swipe the fruit, but in screen, it appear as virtual knife. This game are not in 3D environment.	Stroke	The design of game are suitable for mobile phone or tablet. Stroke patient are prefer computer game rather than mobile game.
Fishing game	VR game	Player is in underwater world using their hand catch fish which are swimming randomly in the water.	One arm	Use head mounted display to see the virtual environment on screen. Use virtual reality controller in order to catch the fish	Stroke	Stroke patient difficult to hold something that is heavy. The game will encourage patient catch fish if they use both hand. This game do not have level of difficulty. It only show virtual hand, not the virtual people that really swimming.
Message a bottle game	Mobile game	Combination of catching the bottle, answering question.	Cognitive	This game not in 3D environment and also not use any virtual reality device.	Stroke	The game only can play in mobile phone or table. It difficult for stroke patient as they cannot hold the heavy thing

There is other game which is fishing game. Player is in underwater world using their virtual hand to catch fish which are swimming randomly in the water. Head mounted display will be use to see the virtual environment on screen. The player use virtual reality controller in order to catch the fish. Instead of holding a controller, uses gloves not only bring patient hands, but also patient fingers into the virtual world [22].

However, there is a mobile or tablet game for stroke patient. The player use finger to swipe the fruit, but in screen, it appear as virtual knife. This game are not in 3D environment. Stroke patient are prefer computer game rather than mobile game. They also difficult to hold something that is heavy, because of their hand is not as normal people. Therefore, in rehabilitations using existing games is challenging for stroke patient. These existing game currently more focus to motor skill not for dual cognitive task. They use controller in order to improve motor skill and mostly, when playing the game, the stroke patient are playing while standing in front of computer.

6. NEED A NEW GAME

Rehab for dual cognitive task requires a specific design and technique. A rehabilitation game for dual cognitive task has yet not been developed [23], [6], [24].

Espy emphasized on the needs to find and develop a suitable game that is a good for rehabilitation. The game should have features and environment that are physically suitable for the patient to play. The dual task should have a variety of cognitive and mobility tasks with different complexity levels for the stroke population and thoroughly evaluates their reliability and validity, including their ability to distinguish fallers [4].

It is important to design the game rehab for dual cognitive task. The game that has all the characteristics for stroke patient is needed to support rehabilitation at home. Rehab for dual cognitive tasks is very important because the tasks are performed in activities of the daily life. Therefore, it can improve the functional daily living of the patient.

7. CONCLUSION

As a conclusion in rehabilitation, there are many existing games that are currently have been use. However, all those game is challenging to be use for dual cognitive task on stroke patient. Therefore, stroke patient need a new game that specific to dual cognitive problem and able helping them to dual task in real life.

REFERENCES

- [1] N. A. Borghese, R. Mainetti, M. Pirovano, and P. L. Lanzi, "An intelligent game engine for the at-home rehabilitation of stroke patients," *SeGAH 2013 - IEEE 2nd Int. Conf. Serious Games Appl. Heal. B. Proc.*, 2013.
- [2] K. Lohse, N. Shirzad, A. Verster, N. Hodges, and H. F. M. Van der Loos, "Video Games and Rehabilitation," *J. Neurol. Phys. Ther.*, Vol. 37, No. 4, pp. 166–175, 2013.
- [3] C. Grace *et al.*, "Stroke Patient Rehabilitation: A Pilot Study of an Android- Based Game," *Simul. Gaming*, Vol. 45, No. 2, pp. 151–166, 2014.
- [4] L. Yang, C. He, and M. Y. C. Pang, "Reliability and Validity of Dual-Task Mobility Assessments in People with Chronic Stroke," *PLoS One*, Vol. 11, No. 1, p. e0147833, Jan. 2016.
- [5] T. H. Costa, B. L. A. Paiva, R. V Menezes, L. T. Ramos, A. G. Lopes, and F. M. Bublitz, "NuSense: A Sensor-Based Framework for Ambient Awareness applied in Game Therapy Monitoring."
- [6] Y.-S. Lee *et al.*, "Neurofeedback Training Improves the Dual-Task Performance Ability in Stroke Patients," *Tohoku J. Exp. Med.*, Vol. 236, No. 1, pp. 81–88, 2015.

- [7] K. McCulloch, "Attention and Dual-Task Conditions: Physical Therapy Implications for Individuals With Acquired Brain Injury," *J. Neurol. Phys. Ther.*, Vol. 31, No. 3, pp. 104–118, Sep. 2007.
- [8] E. S. da Rocha, F. P. Carpes, E. S. da Rocha, and F. P. Carpes, "Impact of two different dual tasks on obstacle crossing in elderly," *Fisioter. e Pesqui.*, Vol. 22, No. 4, pp. 386–391, 2015.
- [9] D. Schoene *et al.*, "The effect of interactive cognitive-motor training in reducing fall risk in older people: a systematic review," *BMC Geriatr.*, Vol. 14, No. 1, p. 107, Dec. 2014.
- [10] O. H. Hassan, S. Z. Abidin, R. Anwar, and M. F. Kamaruzaman, *Proceedings of the International Symposium on Research of Arts, Design and Humanities (ISRADH 2014)*. .
- [11] J. Cheng and C. Putnam, "Therapeutic Gaming in Context: Observing Game Use for Brain Injury Rehabilitation Work-in-Progress CHI 2015, Crossings, Seoul, Korea."
- [12] T. Rach and A. Kirsch, "Modelling human problem solving with data from an online game," *Cogn. Process.*, Vol. 17, No. 4, pp. 415–428, Nov. 2016.
- [13] P. Wargnier *et al.*, "Virtual Promenade: A New Serious Game for the Rehabilitation of Older Adults with Post-fall Syndrome," *IEEE SeGAH*, 2016.
- [14] N. Barrett, I. Swain, C. Gatzidis, and C. Mecheraoui, "The use and effect of video game design theory in the creation of game-based systems for upper limb stroke rehabilitation."
- [15] R. Nouchi *et al.*, "Brain Training Game Improves Executive Functions and Processing Speed in the Elderly: A Randomized Controlled Trial," *PLoS One*, Vol. 7, No. 1, p. e29676, Jan. 2012.
- [16] A. Amory, K. Naicker, J. Vincent, and C. Adams, "The use of computer games as an educational tool: identification of appropriate game types and game elements," *Br. J. Educ. Technol.*, Vol. 30, No. 4, pp. 311–321, 1999.
- [17] J. M. Bullinger, C. Fencott, J. Clay, M. Lockyer, and P. Massey, "Clive Fencott, Jo Clay, Mike Lockyer, and Paul Massey, Game Invaders: The Theory and Understanding of Computer Games," *Int. J. Commun. B. Rev.*, Vol. 7, pp. 1152–1155, 2013.
- [18] "Robotic Approaches for Rehabilitation of Hand Function After Stroke."
- [19] K.-Y. Kang and K.-H. Yu, "The effects of eye movement training on gait function in patients with stroke."
- [20] M. Vandermaesen, K. Robert, K. Luyten, and K. Coninx, "ReHoblet — A home-based rehabilitation game on the tablet," in *2014 IEEE 16th International Conference on e-Health Networking, Applications and Services (Healthcom)*, 2014, pp. 411–416.
- [21] J. H. Choi, B. R. Kim, E. Y. Han, and S. M. Kim, "The effect of dual-task training on balance and cognition in patients with subacute post-stroke.," *Ann. Rehabil. Med.*, Vol. 39, No. 1, pp. 81–90, Feb. 2015.
- [22] Ma, M., & Zheng, H. (2011). Virtual reality and serious games in healthcare. In *Advanced Computational Intelligence Paradigms in Healthcare 6. Virtual Reality in Psychotherapy, Rehabilitation, and Assessment* (pp. 169-192). Springer Berlin Heidelberg.
- [23] X. Gonda *et al.*, "The role of cognitive dysfunction in the symptoms and remission from depression," *Ann. Gen. Psychiatry*, Vol. 14, No. 1, p. 27, Dec. 2015.
- [24] M. Pedraza-Hueso, S. Martín-Calzón, F. J. Díaz-Pernas, and M. Martínez-Zarzuola, "Rehabilitation Using Kinect-based Games and Virtual Reality," *Procedia Computer Science*, Vol. 75. pp. 161–168, 2015.

