Paper Jurnal/Prosiding

by Nanik Anita Mukhlisoh

Visual Cueing Modulation of Cycling Speed for Training Person with Stroke in a Virtual Cycling System

I P D Lesmana[1], N A Mukhlisoh[2]

[1,2]Information Technology Department, State Polytechnic of Jember, Indonesia

[1]dody@polije.ac.id, [2]nanik_anita@polije.ac.id

Abstract. The objective of this study was to investigate manipulation of cycling speed in virtual cycling system to affect person with stroke behaviour in real world. We have developed a virtual reality augmented cycling (VRAC) system to examine vision aspects of person post stroke with less walking ability by modifying virtual environment features which affecting cycling speed including gain, width and difficulty of cycling path. We tested two groups of participants divided into healthy young participants (n=3), and people post stroke (n=2) as all of them cycled using virtual cycling while we modified the features of virtual environment. From the tested result, we only found a slight difference in the behaviour of participants in the same group, but there are significant differences between groups of participants. In conclusion, manipulation of cycling speed in virtual environment had changed cycling behaviour of two groups and assisted to transfer visual information in real world to virtual world.

Keywords: VRAC, VE, cycling speed, gain, path width, path difficulty

1. Introduction

People with stroke have limited ability to conduct physical training because of lost motor skills. To overcome this problem, they should be forced to run physical training regularly by performing same tasks again and again. However, repetition of tasks can raise another problem or become new burden to people with stroke due to monotony of the physical training situation. If this situation happens, it can raise inconsistence training that can lead more severe condition of people with stroke. Providing various challenges using heterogeneous environments can increase adherence of people with stroke to train some tasks regularly and accelerate their motor performance after stroke incident [1]. Motor imagery of brain processing to relearn motor skills is stimulated by performing training in different environments [2, 3].

The constraint in physics of real world can overcome by virtual environments (VEs) that adapt in any situation. To generate perceptual of people with stroke and its motor functions, several environmental scenarios in VEs can be designed by therapist from light exercise level to strenuous exercise level [4]. The main challenge of VEs design is to transfer visual information in real world to virtual condition, so it needs to build immersive virtual environment. We realize that components in real world cannot be visualized completely in VEs. It depends on how VE designer realize human perception of being physically present in virtual world.

For example, in real world, user usually does not think how brain works to capture signal input, process into brain, and result action as body responses. Otherwise, interaction between user and VE must calculate manually several parameters related with a field of view that integrates visual cues in the periphery to enhance immersion and self-motion perception. Thus, user and VE must estimate and make manipulation of spatial frequency between objects in the VE to feel sensation of moving faster or moving slower through environment. User and VE must define color contrast, texture, objects scaled to real world proportion. All objects manipulation is used to influence and improve self-perception of motion. Therefore, limitation of VEs because of spatial and temporal display tolerances must be realized for specific rehabilitation applications.

In previous research, we got information that post-stroke exercise to train gait and walking ability using virtual reality treadmill had resulted in good lower limb treatment [5]. Thus, modification of optic flow speed to resolve abnormal gait in cerebral palsy patients had shown that walking speed, cadence, and step length can follow three conditions of optic flow modulation: slow, normal, and fast to change abnormal gait behavior [6]. Gait parameters such as gait velocity, stride length, and cadence could be modified to stimulate motor function of legs by modulating optic flow [7]. Moreover, a positive change of cycling velocity is affected by modification of optic flow on speed of cycling in young people. However, there was no evidence that optical flow modulation between user and VE will improve gait and walking ability to people with stroke.

In this research, we try to modulate optic flow parameters that affect cycling speed when driving virtual cycling simulator. Detail explanation of virtual cycling simulator has been published in [8, 9]. Modifying optic flow parameters such as gain, path width, and path difficulty will be observed to determine the change of walking behavior of people with stroke and transfer their skills to real-world physics.

2. Methods

2.1. Virtual Cycling Apparatus

Based on [8, 9], design of virtual cycling simulator is shown in Figure 1. Virtual cycling simulator equipped with two pedals and each pedal consists of a load-cell sensor, an accelerometer sensor, and a microcontroller unit with wireless module to transmit data to box control (A). To measure heart-rate (BPM), pedal rotation (RPM), and steering interfaces, virtual cycling has one heart-rate sensor (B), reed-switch sensor, two switches on-off placed at steering bar (C). Box control (D) collects data from virtual cycling modules and process to central processing unit (E).

2.2. Participants

There are two groups involved in this experiment. First group, named healthy young participants, has three participants aged 25-30 years. While, another group, name post stroke participants, has two participants and suffer impaired ability to walk for 1-5 years. All subjects have signed informed consent to participate in this experiment until finish.

2.3. Procedure

First step, subject was positioned on a virtual cycling in Figure 1 with knee flexion at 75°, both hands in the correct position on the handle bar to control bicycle steering. Simulator training divided into three sessions, namely warm-up session, exercise session, and cool-down session. During warm-up and cool-down, subject cycled at 0.5 kg on 50 rpm and maintained training intensity between 20 and 30 beats per minute above resting heart rate of subject. In exercise session, subject cycled in VE from virtual cycling simulator. VE used in this research consisted of two avatars; a virtual rider and a virtual trainer (see Figure 2). Initial cycling speed of trainer was referred to a target heart rate (THR) of rider. Virtual rider kept safe distance from virtual trainer while maintaining his heart rate closed to the virtual trainer's heart rate.

Figure 1. Virtual cycling simulator; A: pedals with balance modules; B: heart rate module; C: steering on-off module; D: control box; E: central processing and display unit.

(a) (b)

Figure 2. VE setting for optic flow manipulation; a) WP with obstacles; b) NP with obstacles

To examine manipulation of cycling speed by modifying optic flow when running virtual cycling, we define two scenarios as follows: in first scenario, we create cycling track having wide path (WP) equipped with boxes as obstacles (simulate as path difficulty). Boxes were place along the cycling track. Moreover, in second scenario, we create cycling track having narrow path (NP) and boxes as path difficulty. Gain parameters divided into three level namely normal gain (NORM), low gain (LOW), and high gain (HIGH). NORM showed that virtual rider and virtual trainer were at close distance and they had matched heart rate. In other words, virtual rider can follow instructions of virtual trainer to cycle behind him with safe heart rate. LOW indicator referred that rider need less effort to catch virtual trainer. Moreover, HIGH was used by virtual rider when distance to virtual trainer was too far to catch up. The condition of path width and path difficulty was used to manipulate optic flow so we can observe the change of behavior of people with stroke to transfer skills in real world settings.

During examination session, virtual rider was instructed to train using two scenarios and cycle following virtual trainer as seen on Figure 2.

3. Results and Discussion

As shown in Figure 3 and Figure 4, both healthy young group and post-stroke group had same pattern to respond optic flow change to VE path designed. In Figure 3, we knew that healthy young participants gave good responses when gain changed. They adjusted their RPM to be higher from VE condition with NP+obstacles to VE condition with WP+obstacles. Moreover, their RPM were also decreased when moving from wide path to narrow path. As seen on Figure 4, the change of RPM from post-stroke group were small when they responded from VE condition with WP+obstacles to VE condition with NP+obstacles.

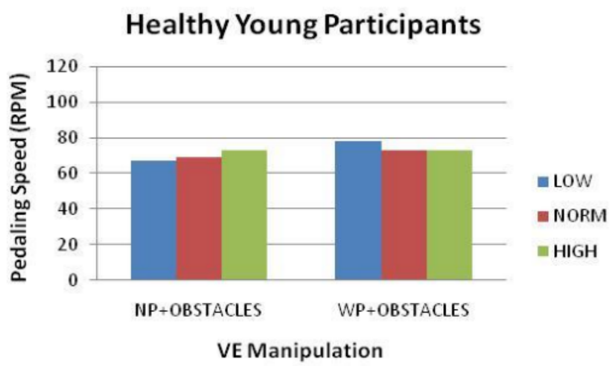

Figure 3. Responses healthy young participants to VE manipulation (path width, path difficulty, and gain) that affect cycling speed

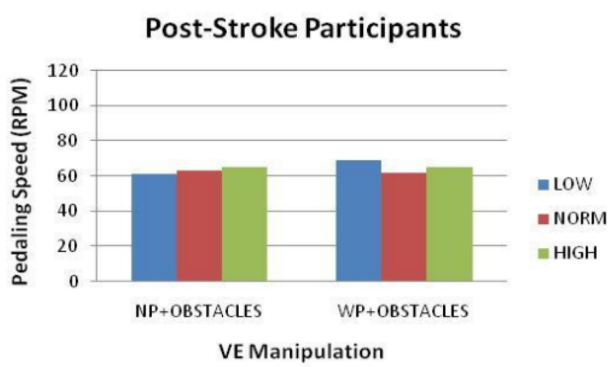

Figure 4. Responses post-stroke participants to VE manipulation (path width, path difficulty, and gain) that affect cycling speed

From the experiment results above, each group gives different responses to change in VE condition including gain, path width, and path difficulty. Healthy young participants give best responses to VE manipulation compared with post-stroke participants. They are more flexible and easily adapt motor movements to change VE condition from narrow path to wide path, where there are small changes in gain and a steady increase in cycling speed (RPM) to follow virtual trainer. Response of post stroke participants to VE condition changes is still low. The significant increase in RPM occurs when they are on the wide path to catch up with the virtual trainer. This is shown from the higher speed values in high gain conditions compared to almost the same speed values between various gain conditions on narrow path. The gain difference is not too significant on narrow path because they require balanced motor coordination in the leg that has motor impairments. Finally, we get input that the VE design for post stroke patients still requires a way to generate greater stimulation of motor movement changes. The changes in motor movement produced by people post stroke are still small when seen in a short training time (±15 minutes). However, in the experiments that have been carried out, VE manipulation that has been created has succeeded in training and improving the walking ability of people post-stroke to be applied to real world condition.

4. Conclusion

The manipulation of the VE such as path width, path difficulty, and gain to manipulate cycling speed or optic flow of virtual cycling can affect behavior changes in healthy young participants and post-stroke participants to be applied to the real world, although the design and manipulation of the VE that has been made still generate low motor stimulus changes in post stroke participants. VE development and manipulation of VE parameters by looking at age, emotion, and clinical pathology will result in a greater stimulation of motor movement in VE.

References

[1] Jarus, T., & Gutman, T. (2001). Effects of cognitive processes and task complexity on acquisition, retention, and transfer of motor skills. Canadian Journal of Occupational Therapy, 68(5), 280-289.

[2] De Vries, S., & Mulder, T. (2007). Motor imagery and stroke rehabilitation: a critical discussion. Journal of rehabilitation medicine, 39(1), 5-13.

[3] Taub, E., Uswatte, G., & Pidikiti, R. (1999). Constraint-induced movement therapy: a new family of techniques with broad application to physical rehabilitation-a clinical review. Journal of rehabilitation research and development, 36(3), 237-251.

[4] Patton, J., Dawe, G., Scharver, C., Mussa-Ivaldi, F., & Kenyon, R. (2006). Robotics and virtual reality: a perfect marriage for motor control research and rehabilitation. Assistive Technology, 18(2), 181-195.

[5] Yang, Y. R., Tsai, M. P., Chuang, T. Y., Sung, W. H., & Wang, R. Y. (2008). Virtual reality-based training improves community ambulation in individuals with stroke: a randomized controlled trial. Gait & posture, 28(2), 201-206.

[6] Lim, H. (2014). Effect of the modulation of optic flow speed on gait parameters in children with hemiplegic cerebral palsy. Journal of physical therapy science, 26(1), 145-148.

[7] Prokop, T., Schubert, M., & Berger, W. (1997). Visual influence on human locomotion modulation to changes in optic flow. Experimental brain research, 114(1), 63-70.

[8] Lesmana, I. P. D., Widiawan, B., Hartadi, D. R., & Al Haris, M. F. (2018). Pengembangan Terapi Cermin Pada Latihan Bersepeda Berbasis Virtual Reality Untuk Meningkatkan Gerak Motorik Ekstremitas Atas Pasca Stroke. Jurnal Teknologi Informasi dan Ilmu Komputer, 5(4), 503-510.

[9] Al Haris, M. F., & Rini, E. M. (2018). Perancangan Dan Validasi Modul Penyusun Serious Game Berbasis Sepeda Virtual Untuk Rehabilitasi Pasca Stroke. Jurnal Teknologi Informasi dan Terapan, 5(2), 113-120.

Paper Jurnal/Prosiding

ORIGINALITY REPORT

11%	3%	10%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	I P D Lesmana, B Widiawan, D R Hartadi. "Manipulation of Virtual Environment to Examine Perception and Vision Aspects of Individuals Post-Stroke When Driving VRAC Simulator", Journal of Physics: Conference Series, 2020 Publication	10%
2	conference.polije.ac.id Internet Source	1%
3	www.scribd.com Internet Source	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		