A SERIOUS GAME DEVELOPMENT FOR GAIT REHABILITATION

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Abstract. *The purpose of this paper is presents a serious game developed for gait rehabilitation to complement treadmill physiotherapy in stroke patient. The game was made using the Microsoft Kinect, the game engine Unity 3D and a treadmill to create a serious game with needed parameters to gait rehabilitation. We hope that this game will increase the patients' motivation with visual feedback that can promote better results treatment.*

Keywords*: Gait rehabilitation. Serious games. Physiotherapy. Stroke rehabilitation.*

1. INTRODUCTION

(ZYDA, 2005) defines serious games as "mental conquest, play with a computer in accordance with specific rules, which uses entertainment to further government or corporate training, education, health, public policy and strategic communication objectives". They involve pedagogy, imparting knowledge or skills through activities that educate or instruct.

Stroke is, worldwide, the leading cause of death and disability in adults. It is estimate that about 57% of stroke survivors will need ongoing care (KARENY et al., 2016). According to the World Disability Report published by the World Health Organization (WHO), more than 1 billion people around the world are living with some kind of disability, making it a matter of rights rehabilitation, among others (BRASIL, 2013).

After being affect by a stroke, patients suffer neurological losses that will interfere in cognition, communication, emotionally and especially, in the neuromuscular system. The main losses in these individuals occur in abnormal gait pattern, hemiparesis, loss of balance and muscle spasticity (BELDA-LOIS et al., 2011; LOTERIO, 2015).

The hemiparetic gait, that is, the human gait in patients who have loss of sensitivity of one side of the body, is neither coordinated nor rhythmic, consuming high energy content of the human being, besides not having the necessary balance (OTTOBONI et al., 2002).

For most injuries, rehabilitation is a long and arduous process where patients and practitioners face a variety of problems with varying backgrounds, such as motivation. Thus, the use of technologies that make these processes less methodical and tiring causes patients to feel immersed in the treatment, generating even more results (WEISS et al., 2004).

The object of this paper is presents a game for complement treadmill physiotherapy in gait rehabilitation from stroke patients. This game has a strong potential to better improve interest of the patient throughout time. In the following sections, the serious game and the visual real-time feedback of the avatar based on the Microsoft Kinect will be presented.

2. THE GAME AND VISUAL REAL-TIME FEEDBACK

The developed game, Fig. (1), is an endless runner with Unity 3D game engine, where an avatar walks on a wood planks bridge. The game followed the model of the sensor-motor theory of gait presented in (HOGAN; STERNAD, 2012), that takes into account walking in real life with all its variations, as discrete movements, rhythmic movements and balance. The plank pattern generation on the bridge makes the avatar walks in different ways, with long and shorts steps.

The avatar's speed is function of treadmill speed, and the patient movements are copied by avatar in game. These parameters make the game more realistic, once the speed is highly configurable and gait rhythm and balance is equally repeated by the avatar.

Besides, there are some obstacles that will appear randomly over the bridge to stimulate the patient to execute different movements with the body to avoid them. These obstacles are intend to bring more visual cueing to improve the cognition, balance, and superior limbs rehabilitation, who are included in normal human gait parameters (OTTOBONI et al., 2002; IWABE et al., 2008).

The avatar model was made by (FILKOV, 2014) and it was adaptable to belong the game. This Unity 3D asset has an avatar model including its kinematic model and control scripts. From these, the control and games scripts were developed to achieve the study objectives. It uses the image processing from Microsoft Kinect, Fig. (2), and apply mapping, filters and controls algorithms to make the manipulations and data acquisition possible. This asset has a free distribution for researchers.

Figure 1. The developed game is an endless runner with Unity3D game engine, where an avatar walks on a wood planks bridge.

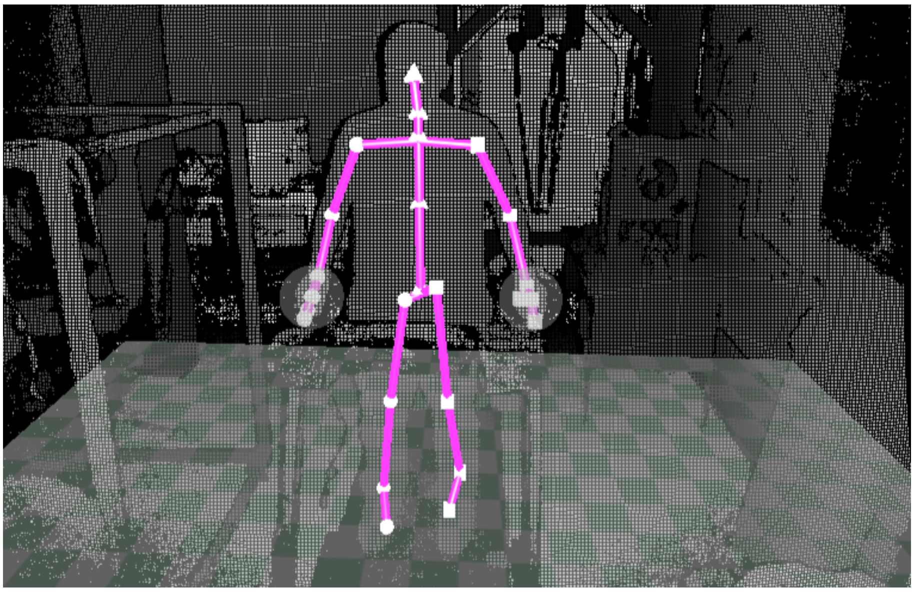

Figure 2. The image processing from Microsoft Kinect identify the skeleton structure and joints in our setup.

The primordial game action is to give a great visual real-time feedback. This feedback will increase the patient experience during the game and will improve the motivation level throughout therapy.

The main script works to capture user movements and, by storing all the positions of the body mapping parts into specific variables for each of those parts, it transfers that information to the avatar. Using a transformation function to identify the positions, rotations and scales of information passed by the user's Kinect sensor images, the script performs a transformation to initialize these variables from each body part. And, to save these positions, it creates a three-dimensional vector.

After the setup information, the script is responsible for repeating the analyzes of the joints positions and rotations to each frame and updating them to transfer the information to the avatar. Besides this main algorithm, there are others to control the game's parameters, as avatar's speed, camera movement, and game's conditions.

3. USABILITY TESTS

It was used a Game Experience Questionnaire (GEQ) to analyzed the player game immersion. The GEQ tests have seven distinct dimensions in players experience: Sensory and Imaginative Immersion, Tension, Competence, Flow, Negative Affect, Positive Affect, and Challenge (APPL et al., 2008).

To quantify these affirmations, we chose to use the Likert scale, a scale that has five points, widely used in the context of behavioral sciences. It consists of, from an affirmation, the respondents will issue their degree of agreement (SILVA JÚNIOR; COSTA, 2014).

The GEQ was performed with 10 healthy players. Thus, it represents only a view on the entertainment side of the game. The values resulting from the test are shown in Fig. (3) and may be different when the game will be test on a sample of post-stroke players.

Figure 3 shows GEQ answers and it could be noted the effectiveness of even in defining as the players' views regarding the game, since they are the same ones reveal quiet in relation as affirmations and degrees of concordances of the Likert scale.

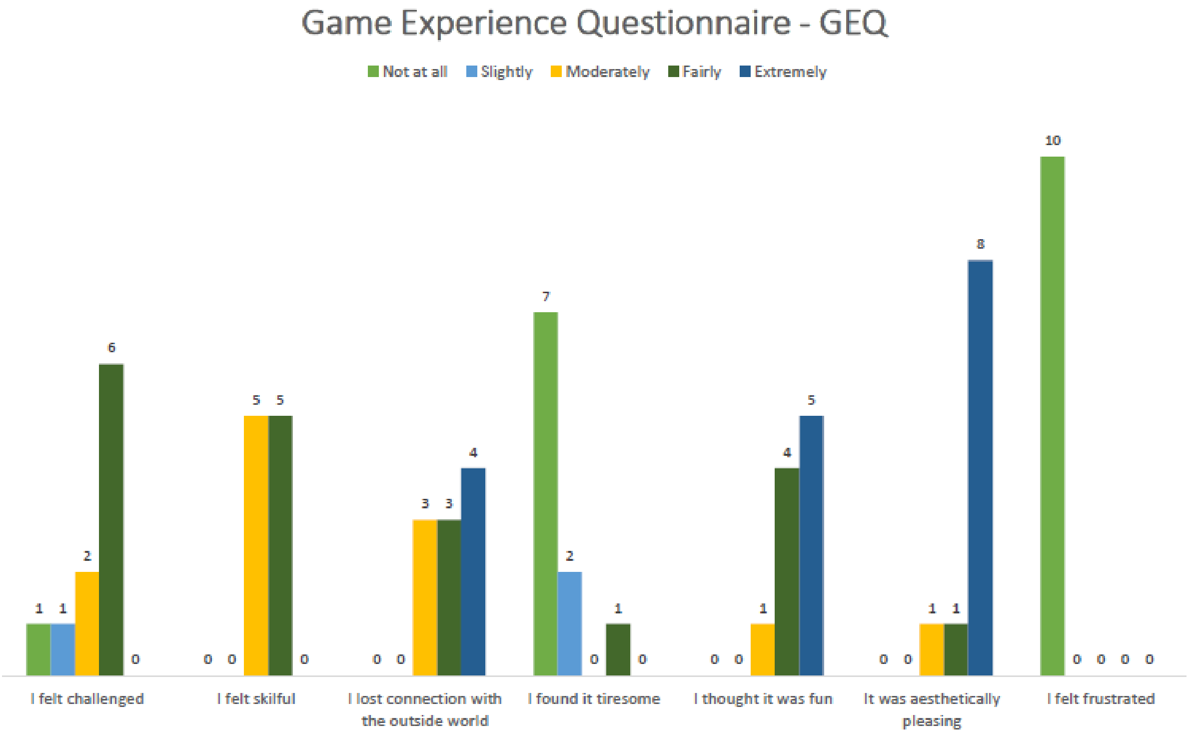

Figure 3. The Game Experience Questionnaire responses performed with a healthy stock sample.

3. CONCLUSIONS

This paper presented a serious game to gait rehabilitation. The game was developed using the device Kinect and the software Unity 3D. Through the tests performed with ten healthy players, it was possible to notice a positive impact on them. Indicators of positive aspects of the GEQ generated a high level of agreement, while the indicators of negative aspects generated a low degree of agreement of the players. Through this information it is possible to move on to new steps, allowing the game to be improved and tested on players with gait problems.

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6. INFORMATIONS RESPONSIBILITY

The authors are the only responsible for the information included in this study.