Towards Bilateral Upper-Limb Rehabilitation after Stroke using Kinect Game

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***Abstract*—This paper presented a game-based rehabilitation of the upper limb after stroke. We designed and developed a game for supporting stroke patients to have an exercise their arms, and the game had functions for recording their playing and showing a performance report. The performance report can infer the progress of bilateral uppper-limb rehabilitation and use for comparing among patient cases. This is because the game used a Kinect device to detect the arm movements in aspect of precision and speed.**

***Index Terms*—Home-based Rehabilitation, Serious Games, Kinect device**

I. Introduction

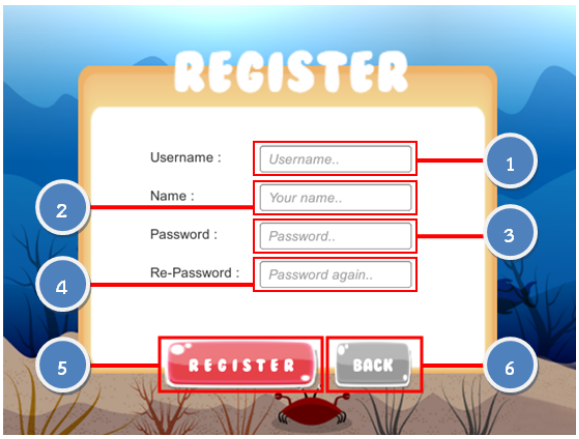
Thailand has a national health care system, which is available to all other Thai nationals. Stroke was the third rank of causing death recording, and it was the leading cause of long-term disability. Stroke also was a major health burden in the national health system. Due to the cost barrier, in-patient rehabilitation length of stay for patients with stroke has been decreased and outpatient physiotherapy rehabilitation is typically only a couple times per week. A home-based rehabilitation program will compromise the cost of outpatient physiotherapy rehabilitation, but it requires a user-friendly system as well as easy setup system. This paper presents a home-based rehabilitation system, which is a game-play using a Kinect device.

II. Home-based Rehabilitation

There was a study on the comparison on home-based and center-based rehabilitation, and it found that no significant difference in term of numbers of deaths, exercise capacity and health-related quality of life [1]. A game technology has been a major supporting part for building a home-based rehabilitation with the objective of making therapeutic exercise fun and contextual. With gaming devices such as Microsoft Kinect and Nintendo Wii, there were clinical research reports that they appeared to be a feasible adjunctive device to augment conventional therapy in a cohort of subacute stroke patients with moderate impairments of upper limb strength [2].

Health promotion and rehabilitation into game has been fun and innovative by using commercial off-the-shelf gaming devices, i.e. Nintendo Wii and Microsoft Kinect as reported in many publications [3]–[5]. For stroke rehabilitation, the study by [3] conducted the experiment with 16 subjects and found that the game with Wii were enjoyable and comparable to, if not better than, conventional therapy.

III. Game Design for Bilateral Upper-Limb Rehabilitation



(a) Register page

(b) Game playing window

Fig. 1. Bubble Game for bilateral upper-limb rehabilitation.

Our game design focused on bilateral upper-limb rehabilitation by encouraging patients to control their both left and right arms movements in a particular direction, named ”Bubble Game”. Bubble game is that a player must touch bubbles to get points. The game begins with big bubbles moving slowly from the bottom to top scene. The size of bubbles will be gradually decreasing, but their speed will be increasing. The goal of this game is to motivate the patients to move their

arms as much as possible, and also control their arms in the desired direction in order to earn high scores from the game.

A register page will be popped up immediately after starting the game as shown in Fig 1 (a), and a game window will be appeared after the registration as shown in Fig. 1 (b). In Fig 1 (a), the game requires a player to fill his/her username, name, and password. In Fig. 1 (b), while a game play, the time left and the score will be displayed.

To use a game for rehabilitation, the in-game play data must be recorded and analyzed, and the list of recorded data are shown below:

- touched bubbles: total number, sizes, touch hands (left/right)
- hit rate, miss rate of touched bubbles

As well as all players must be registered, and their log-in and log-out date and time will be used in analysis with the in-game play data. These information can be illustrated in a format of a graph performance shown in Fig. 2 after the end of game.

A. Usability Testing

1) Participants and Procedure: In this study, we recruited the participants by sending emails to faculty staffs and students, and we received 15 respondents of aged between 25 and 55 years old. For the testing procedure, we presented our research proposal, and then volunteers put their name in the list to play a game and win the prize. All participants spent five minutes to finish the game.

2) Data Report: After the end of game, the graph performance will be displayed by using color dots plotted in xy coordinate. Color dots represented the bubble speed, i.e., blue, orange, and green are speed at 2, 4, 6, respectively. Blue dots mean slowest, and green dots mean fastest. The graph performance shows the following information:

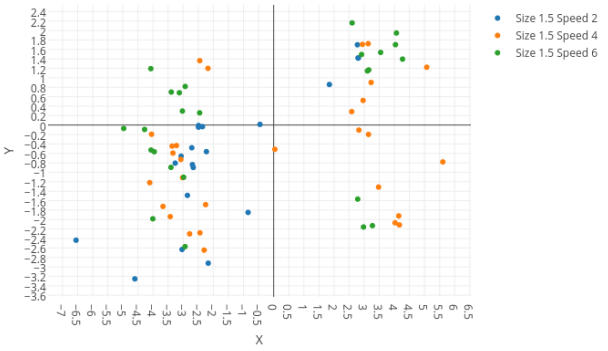
- how far a player can raise his/her hands,
- how fast a player can move his/her hands, and
- how long a player can move and raise his/her hands.

The graph performance can be used to compared between two players as well as showing their progress from the past. For example, Fig. 2 (a)-(b) corresponding to player 1 and 2 can infer as follows:

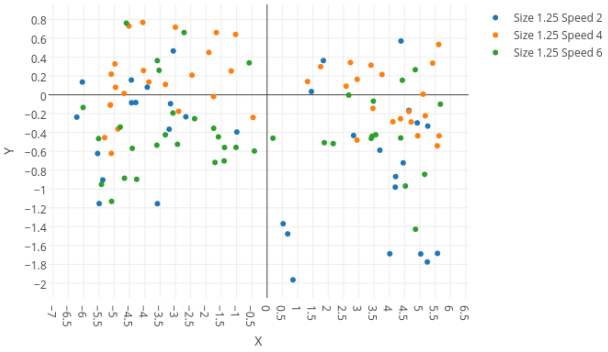
- the total number of touch bubbles showing that player 2 touched more bubbles than Player 1 did,
- the position of touch bubbles showing that player 2 touched more bubbles in high position than Player 1 did and
- in conclusion, player 2 had better performance than player 1 because player 2 tried to raise her hands up and high, but player 2 did not.

IV. Results and Conclusions

In preliminary results, we found that gender, weight, height did not make different in game performance significantly at $p = 0.05$, but age. The ages above 50 years old showed significant difference in game performance at $p = 0.05$. Their speed were slower and got a lower score than younger players.



(a) a game performance of player 1



(b) a game performance of player 2

Fig. 2. Game-play results showing the arm strength (rehabilitation improvement) of two players (a)-(b) .

The feedback from players was that this game design was attractive, easy to understand, simply to play, and short-time exercise. Players could be very quickly understand the game play, and spend only five minute to finish the game. Some feedback said that their arms were fatigue like a real exercise after playing the game.

This paper developed a prototype of Kinect-based game towards stroke rehabilitation at home. This can be used for health promotion for all ages and genders. For a use of rehabilitation, this game should be used under specialist nurse or carer to observe adverse events, such as fatigue, stiffness or pain.

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