LOW-COST VIRTUAL REALITY GAME FOR UPPER LIMB REHABILITATION USING KINECT AND P5 GLOVE

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INTRODUCTION

After stroke, more than 50% of survivors report disability of upper extremity function even after conventional treatments [1]. Continuous intensive rehabilitation therapies in a virtual environment may enhance recovery [2]. However, access to virtual reality rehabilitation systems is currently not optimum due to high costs [3]. The need for low-cost virtual reality rehabilitation systems for use in clinics or at home is clear. The objective of this study was to develop a low-cost virtual reality game to engage patients in interactive kitchen activities for rehabilitation using low-cost commercially available motion tracking devices

METHODS

We have developed a virtual reality kitchen game for upper limb rehabilitation using two low-cost motion tracking devices, Kinect (Microsoft, Redmond, WA, USA) and P5 Glove (Essential Reality, LLC, New York, NY, USA) (Fig. 1). Kinect is used to detect the 3D position of the whole arm. The P5 Glove is used to capture the flexion/extension of individual digits and the 3D position and orientation of the hand.

The 3D virtual kitchen environment was developed using open-source software, Blender (Fig. 2). Users can interact with objects in the kitchen by moving their hand and arm whose motions are detected by the motion tracking devices and mimicked by the virtual hand and arm in the kitchen in real time (Fig. 3). A client program receives the joint position data from the motion tracking devices and transmits it to the server program (game engine in Blender) through a User Datagram Protocol connection. The server program then computes joint angles and maps them to the virtual arm. The virtual arm thus follows the user movement.

Compensatory movements such as reaching by moving the trunk [4] are programmed not to contribute to arm reaching to guide users toward normal reaching motion. To enhance the sense of reality, gravity is simulated in this kitchen such that objects fall to the floor if a user drops or pushes them.

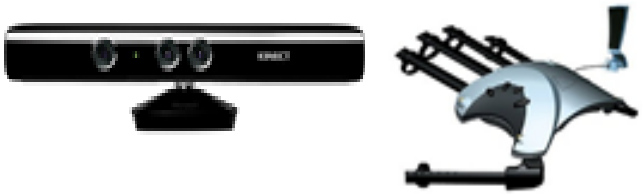

Figure 1: Motion tracking devices used in the game (www.microsoftstore.com, vrealities.com)

Figure 2: 3D kitchen environment developed

Figure 3: Virtual arm reaching to grasp a glass

The game requires a user to perform a variety of functional tasks that involve grasping, moving and releasing of kitchen items, inspired by the clinical test, Fugl-Meyer Assessment. These tasks focus on individual and mass flexion/extension of the digits, grasping objects in different sizes and shapes, forearm pronation/supination, elbow extension, and shoulder abduction. For instance, the user is asked to move different items (plates, glasses, soda cans, soup cans) from the counter to an overhead shelf or from the overhead compartment to the cabinet under the counter to practice reaching and grasping motions.

In another task, the user has to pick up assorted utensils such as spoons, forks and knives one by one from the countertop and place them inside a drawer to practice precision grasps. The user is also asked to put toppings on a pizza or prepare salad using multiple ingredients to practice hand and arm coordination. The ingredients are in various shapes and sizes (e.g., pepperoni slices, salt shaker, dressing bottle, lettuce) to expose the user to various grip postures. In addition, the user is asked to flip an hour glass, dial a rotary phone, and wipe the table with a kitchen towel to practice other functional movements with the arm and hand.

To motivate the user, points are awarded per good performance by the user. If the user picks up a wrong item, places an item in an incorrect location, or performs with undesirable hand/arm postures, partial credits will be given. These points are stored to track and display to the user their own progress over repeated game plays.

RESULTS AND DISCUSSIONS

We have developed a virtual kitchen rehabilitation game containing a dynamic virtual arm. The virtual arm follows the user movement in real time well enough for playing the game. However, the need to improve accuracy and remove occasional jittering for the virtual arm movement exists for aesthetics and sense of reality, possibly by enhancing filtering and motion description algorithm for the data obtained from the low-cost devices. Additional future work includes user–specific calibration to accommodate patients with different functional capacities or ranges of motion and refinement of instructions for users.

This kitchen game with Kinect and P5 Glove demonstrates strong potential and feasibility for low-cost rehabilitation game systems for home or clinic use. The expected cost for this system is $310 for the hardware, as can be seen in Table 1. The game setup and content is designed to provide entertainment along with physical activity needed for rehabilitation.

CONCLUSIONS

We have developed a low-cost virtual game for patients to perform kitchen activities as a game with the virtual arm and hand. This kitchen game has the potential to complement occupational therapy and improve sensorimotor function of impaired hand and arms. Upon further technical and instructional improvements of the game, evaluation of the game for patients with hand/arm impairments will be performed to determine clinical efficacy and define future improvement needs.

REFERENCES

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4. Cirstea MC, et al. *Brain*, **123**, 940-953, 2000.

Table 1: System cost analysis

System component	The current system	Other options
Arm motion detection system	Microsoft Kinect ~ $250	Optotrack ~$60,000
Finger motion detection	P5 Glove ~ $60	CyberGlove ~$10,000
Programming Toolkit	Blender (free software)	WorldToolKit ~$6,000