Game Development For Sensorimotor Upper-Limb Rehabilitation After Stroke

Alberto Garzás Villar

Supervisors: Prof. Dr. Laura Marchal-Crespo, Raphael Rätz
Institution: University of Bern, ARTORG Center for Biomedical Engineering Research
Examiners: Prof. Dr. Laura Marchal-Crespo, Raphael Rätz

Introduction

Stroke can not only be classified as one of the leading causes of death in the world, but also one of the biggest causes of disability. Among many other possible disabilities, we find that the upper limbs are often impaired after stroke. This has a great impact on performing activities of daily living by the affected population. Although intensive rehabilitation is recommended, most patients will find this process tedious and repetitive, which can affect their engagement. To address this, the creation of a serious game was proposed. Taking advantage of haptic technology that allows to simultaneously train motor and sensory functions, virtual training tasks were designed.

Materials and Methods

The design of this game was intended to complement a prototype of a haptic upper-limb rehabilitation device that allows performing finger and thumb movements as well as translational displacements. This gave us the possibility, among other things, to interact with virtual objects.

Fig. 1 Prototype of haptic upper-limb rehabilitation device.

The design of the game was divided into three main stages. First, a literature review was carried out complementing information received from interviews with therapists. Using this information, a list of requirements for the game was drawn up. Then the game was designed in C# using the Unity 3D game engine. At the same time, the custom control software of the haptic device, written in C++ was extended to accommodate game-specific haptic interactions and functionalities. Finally, two assessment with therapists were carried out. One during the development process and another one at the end.

Results

A simple user interface and a multitask game were created. Three modes according to different impairment levels of the patients were included. Moreover, two game levels were introduced to ensure difficulty variation.
The result was a first-person game in which patients are asked to hit different targets by using a large slingshot. In this task, not only finger flexion and extension movements are trained, but the interaction forces with the slingshot are also a source of somatosensory information for sensory training.
The game concept offers a wide range of possibilities to adapt to patients' needs as the movement and position of the targets can be easily varied.

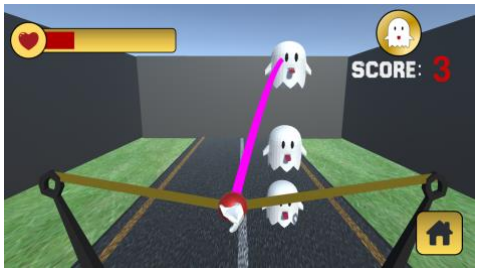

Fig. 2 Gameplay scene: The goal is to hit the incoming targets (ghosts). A scoring system was created to increase engagement while a trajectory prediction can be used to facilitate the aiming.

Discussion

The designed game is promising. Although it is still a developmental version, users were highly engaged during testing, and therapists' assessments have been very positive. It has been carefully designed in a way to allows it to be easily modified and extended. Therefore, it has the potential to be further developed into a mature game for robotic upper-limb rehabilitation.

References

Rätz R, Conti F, Müri R, and Marchal-Crespo L. (2021). A novel Clinical-Driven Design for Robotic Hand Rehabilitation: Combining Sensory Training, Effortless Setup, and Large Range of Motion in a Palmar Device. *Frontiers in Neurorobotics.* 15.

Acknowledgments

Special thanks to Prof. Dr. Laura Marchal-Crespo and Raphael Rätz for their supervision and thanks to the whole MLN Laboratory in ARTORG.