Portable Hand Training System for Unsupervised Home Rehabilitation

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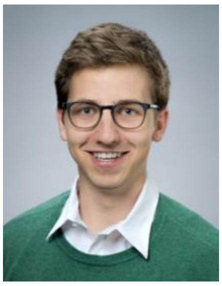

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Introduction

Stroke remains a major cause of disability. Stroke can lead to severe impairments in the upper limbs, which affect patients' ability to perform activities of daily living. Clinical evidence shows that high intensity and somatosensory training are key factors to maximize recovery. Robotic devices incorporating haptic rendering can deliver both somatic feedback and endurance by incorporating engaging virtual environments. Here we present a simple and intuitive device suited for unsupervised sensorimotor training to help overcome limits in the availability of therapists to promote recovery.

Materials and Methods

The goal of this thesis was to build a finished and improved hand trainer prototype developed in a previous Master's thesis, which can be used in unsupervised clinical environments, based on a flexible shell design. To ensure maximum comfort for patients with different hand sizes, optimal dimensions and shapes for three different shells were determined. Based on anthropometric data, two simplified 2D hand models were created. Endpoints of a cubic B-Spline with constant length clinging to the contact surface of said hand models, representing the flexible shell, were registered for different grasping angles of the hand.

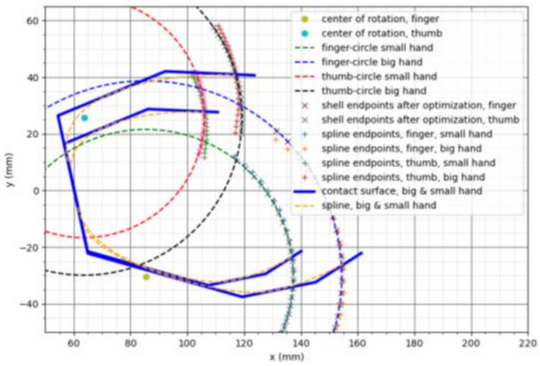

Fig. 1 Python plot showing hand contact surfaces, splines representing the shells and optimization results

Optimal centers of rotation for actuation of the shell, lever lengths, and angle offsets for both thumb and finger of the small and large hands were found with the help of differential evolution optimization to match the data points. The medium shell was linearly interpolated in between big and small hand sizes.

Results

A new finished device for unsupervised training was developed, which can be used to safely and intuitively train grasping movements in stroke patients with different hand sizes. Haptic rendering enables somatosensory training in addition to motor functions in a motivating virtual environment.
An improved transmission reduces friction and play. A simple and clean design improves its use intuitiveness, while different shell sizes ensure maximum comfort and correct movements during training. Shells can quickly be changed without special tools. To ensure safety, the device covers, which prevent any pinching of the fingers, snap into place with magnets. By tilting the device, small pronosupination movements were allowed, and by using an IMU those movements can be employed for easy navigation on virtual reality games.

Fig. 2 Prototype with small shell and adjustable finger and wrist fixations for unsupervised sensorimotor hand training

Discussion

The portable device for unsupervised sensorimotor hand training combines important factors in rehabilitation after stroke. Improvements have been successful and the device can be used for studies and tests with therapists and patients.

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

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