Mirror Therapy Using Virtual Reality and Actuated Exoskeleton: Road to a Patient Care Device

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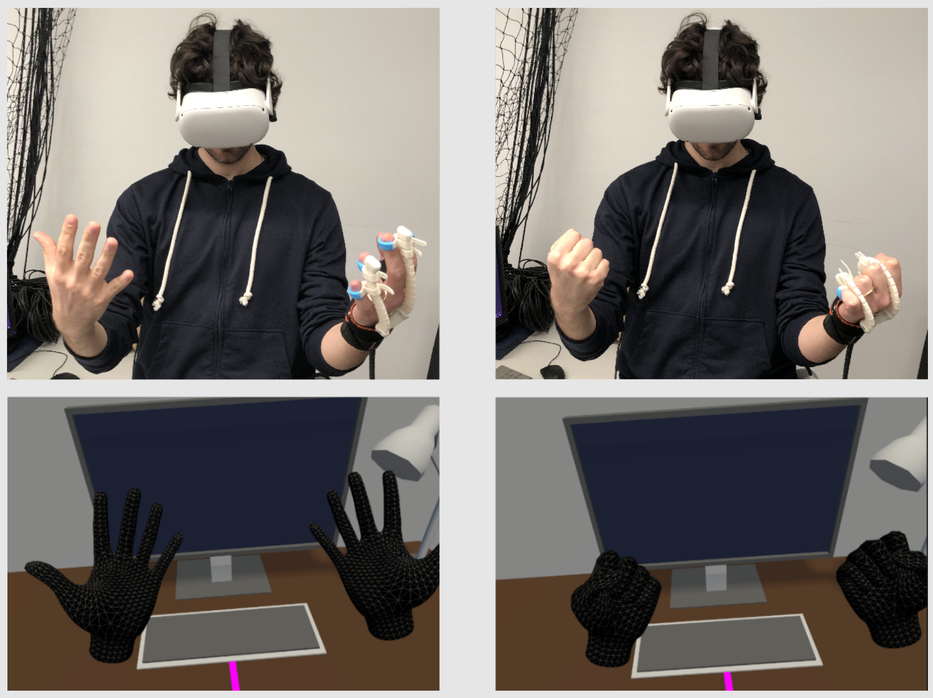
Virtual Reality (VR) and Hand Exoskeleton for Mirror Therapy (MT)

In *standard MT* setups:
- Users move their healthy hand in front of a mirror
- The mirrored hand is perceived in place of the impaired one
- The illusion provoked by the mirrored visual perception stimulates *neuroplasticity*

Immersive VR replaces the mirror to create a deeper illusion:
- The virtual healthy hand tracks the motion of the real healthy hand
- In the VR scene, the impaired hand mirrors the motion of the healthy hand

The motion induced by a *hand exoskeleton* is coupled with the visual perception:
- The exoskeleton provided by Emovo Care is worn on the impaired hand
- The control aims at zeroing the difference between the virtual mirrored hand and the real one

Tests with healthy subjects [1] show our system to be:
- *Usable*, *accepted by users*, and provides a good *sense of embodiment*
- Promising for future validation with *patients*
- Interesting for application in the field of *telemedicine*

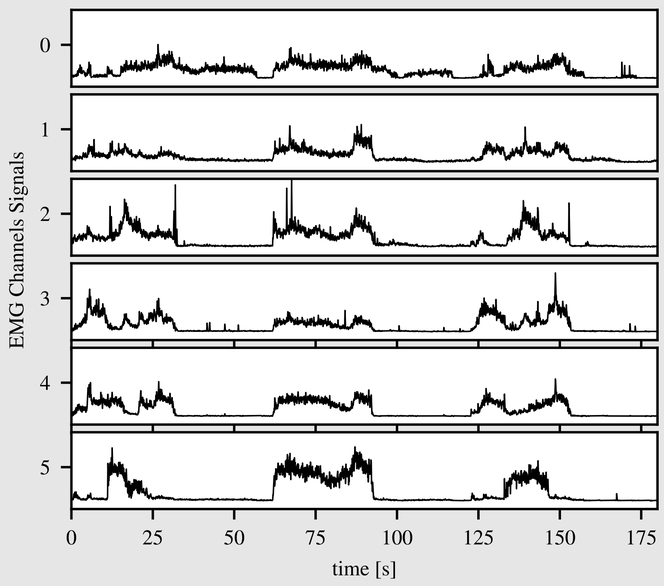


Enhancement of the Sensory Equipment

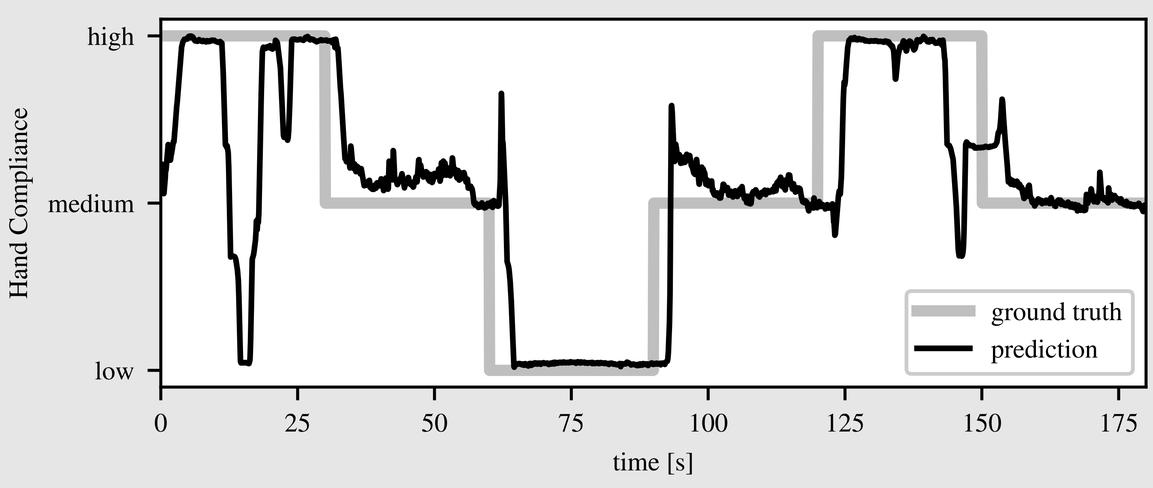
We aim at equipping our device with lightweight sensing to:
- Keep it *portable*, *easy to use*, and *relatively inexpensive*
- Provide complementary information for rehabilitation

Electromyography (EMG) is a suitable option as it:
- Is provided by light and easy-to-wear sensors
- Allows perception of muscular activation
- Enables adaptive exoskeleton behavior

Challenge: EMG signals are noisy



Current work: ML tool to predict the *hand compliance*



Online Assessment of the Therapy

Current therapy assessment suffers from therapist's *subjective* evaluation and low *reliability* and *standardization*

Robotics can *objectively* assess therapy by using proprioception and haptic perception

Wearable EMG, tactile, and force sensors can be integrated to provide our system with online therapy assessment without affecting the portability and lightness of our tool

Current investigations explore ML to fuse data from different sensors and measure the *therapy outcome* (e.g. measuring fingers' range of motion)

Validation with Patients

Test with a small pool of patients in order to validate user study done with healthy users [1] and avoid complex regulatory and logistic challenges

A full-fledged *clinical trial* would follow to validate the impact of our tool from a therapeutical point of view

Conclusions

A MT setup for rehabilitation of hand impairment:
- Enhanced with VR and robotics
- Lightweight and portable
- Deemed usable and safe by healthy users

Challenge: augment our tool's possibilities keeping the setup safe and simple

We propose to integrate wearable EMG to achieve:
- Advanced exoskeleton control
- Online quantitative assessment of the therapy

Test with patients are necessary to:
- Confirm results obtained with healthy users
- Validate the therapy outcome of our tool in a real clinic rehabilitation setup

Previous Work

[1] Abbate, G, Giusti, A., Randazzo, L., Paolillo, A., "A mirror therapy system using virtual reality and an actuated exoskeleton for the recovery of hand motor impairments: a study of acceptability, usability, and embodiment."
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