Body Representation in Physical and Virtual Reality with Application to Rehabilitation
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# Motor and Cognitive Restoration in Virtual Worlds

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## Motivation

Repetitive gait or arm training has been shown to improve limb function in patients with motor disorders after stroke or SCI. It was observed that more and longer training sessions have a positive effect on the motor function. This motivates the application of robot-aided therapy. Robots can make movement training more intensive, while unburden the therapist from a monotone or even exhausting physical task. So-called patient-cooperative robotic controllers, take into account the patient’s intention and efforts rather than imposing any predefined movement. Furthermore, the use of Virtual Reality (VR) technology can improve the patient motivation and, thus, increase not only motion intensity during the training session but also therapeutic compliance during the entire course of a rehabilitation program. We believe that cooperative and VR-supported robotic approaches can have a stronger effect on the restoration of motor and also cognitive functions compared to conventional approaches.

## Methods

We are developing novel patient-cooperative robotic approaches, where audiovisual displays are used to present a virtual environment and let the patient perform tasks and activities of daily living. The human is integrated into the loop not only from a biomechanical view but also with regard to psycho-physiological aspects. Biomechanical integration involves ensuring that the system to be used is ergonomically acceptable and force-reactive. Psycho-physiological integration involves recording and controlling the patient’s physiological reactions so that the patient receives appropriate stimuli and is challenged in a moderate but engaging way without causing undue stress or harm.

## Results

Several patient-cooperative approaches were implemented and tested on the arm therapy robot ARMin and the gait robot Lokomat. We could show that the mechanical integration of the patient increases muscular participation (higher joint torques, EMG activity and heart rate HR). With the Lokomat we were able to control HR and keep it in a desired range by changing walking speed or task difficulty. In another application with the Lokomat, we could show that physiological and psychological states could be influenced by the choice of the virtual scenario and task.

## Conclusion

The patient-cooperative human-in-the-loop structure allows optimizing biomechanical or mental engagement of the subject. This has the potential to increase motivation and, thus, training efficiency and therapeutic outcome. Our strategies guarantee that the patient is training in a safe region by keeping relevant physiological values (e.g. HR) in an appropriate range. Currently, we develop a novel cognitive training environment, which will allow transferring our knowledge also to the cognitive training of dementia patients.