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Title
Hybrid Upper Limb Orthosis

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Summary
The project aims at the development of a portable system for the upper extremity, that combines joint stabilisation, external power from fluidic actuators with inherent compliance, FES and a natural control system that allows the tetra-plegic user to regain independence.

Introduction
In Europe every year 11.000 new patients suffer from a spinal cord injury resulting in a lifelong dependency on caregivers. The objective of modern rehabilitation medicine is to at least partly restore the individual functional deficits. Today, in acute patients a task-oriented, function-specific training of high intensity is performed soon after the lesion to restore the function to a certain extent by enhancing neuroplasticity on spinal and supraspinal levels. Up to now most therapeutic systems are stationary floor-mounted robotic systems and their application is limited to the clinical environment due to their size and complexity. There is a lack of portable home-use training systems for the upper extremity that support patients during activities of daily living. Functional Electrical Stimulation (FES) is one viable option for restoring the grasping function. However, its application is limited to maintain the upper limb against gravity due to muscle fatigue.

Methods
Grasping can be generated by pairs of surface electrodes for stimulation of the finger extensors (M. ext. digitorum communis EDC), the thumb extensors (M. ext. pollicis longus EPL) and one pair for common stimulation of the finger (M. flex. digitorum superficialis FDS und profundus FDP) and thumb flexors (M. flex. pollicis longus FPL). Realignment of the custom made (double sided self-adhesive conductive gel) surface electrodes and their connection to the stimulator is simplified by the use of an elastic textile sleeve with integrated cable structures and arrays for
contacting the stimulation electrodes. For electrical stimulation a Motionstim 8 stimulator with
biphasic constant current pulses with a magnitude of 30 mA, a stimulation frequency of 20Hz
and a pulse width of 200µs were used. The elbow joint is supported by pairs of antagonistically
working miniature fluidic actuators. The residual activity of weak muscles is monitored by an
array of surface EMG electrodes.

Results
The custom made double side adhesive electrodes showed good electrical properties to be
used for long term monitoring of weak EMG signals.
An artefact free EMG signal for real-time processing is needed to control the orthosis.
Therefore, an existing EMG amplifier has been modified detecting the onset and end of a
stimulation pulse generated by stimulation electrodes near the recording site, suppressing
the artefacts by switching the amplification factor and the cut-off frequencies of the filters and
amplifying the EMG activity within the stimulation pulse pauses.
The flexible fluidic actuators generate an elbow joint moment of 6 Nm and allow for elbow
flexion within one second.

Conclusion
The basic concept for a novel hybrid orthosis for both training and functional support is
presented for patients suffering from high spinal cord injury, which will combine both FES and
additional external force generating components namely flexible fluidic actuators. Safety is
ensured by inherent compliance of the actuators, by mechanical stops and by careful limitation
of the maximal moments that are applied to the upper limb. The first prototype of an elbow
flexion orthosis serves as a testbed for a modular system to be developed that will also include
adjacent upper limb joints, such as shoulder and wrist. The overall aim of the project is to
design a portable training device for the whole upper limb that meets the requirements of being
light-weight, compact, and inexpensive. The upcoming clinical tests of the device with selected
patients with preserved shoulder but missing hand and elbow function will provide information
about its basic functionality and usability.
References

Image: Hybrid Orthosis_None.jpg