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Iteratively Learning Electromyography (EMG)-based Functional Electrical Stimulation (FES) for Stroke Rehabilitation

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Introduction

Rehabilitation after stroke can be improved by EMG-proportional FES. While the muscle is being stimulated proportional to its detected residual voluntary activation, the patient practices to reach pre-defined joint angles iteratively. Often the patient has bad control over the movement and oscillations occur. A potential reason is the nonlinear static EMG-angle relation resulting from EMG-proportional stimulation. This contribution describes the development of an improved EMG-based FES system that iteratively learns the nonlinear EMG-FES relation that leads to a linear relation between EMG and joint angle.

Methods

Stimulation of wrist extensor is considered. EMG is measured directly from stimulation electrodes. Starting with proportional EMG control, the subject is asked iteratively to track different patient-typical EMG levels using visual feedback. The resulting joint angles for each EMG level are measured and used to update the EMG-FES relation from iteration to iteration until the desired linear EMG-angle relation is established. In a second step the subject is asked to track a number of reference joint angles while the EMG-FES relation will be set to the nonlinear relation that the algorithm converged to.

Results

Healthy subjects were able to easily track pre-defined EMG levels. Within three iterations the system generated an almost perfectly linear EMG-FES relation. This was found to give the subject good control over his movement.

Conclusion

We developed a learning EMG-based stimulation system that establishes a linear EMG-angle relation. This was demonstrated to give good FES-supported joint angle tracking in healthy subjects. Stroke rehabilitation patients are expected to benefit from the new system. According clinical studies will be performed.