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BACHELOR THESIS / MASTER'S THESIS

Learning for control of wrist-hand movements based on Functional Electric Stimulation

Problem description:

Functional electrical stimulation (FES) is a treatment that artificially activates muscles during exercise and activity for patients with motor disability. This is achieved by placing electrodes on the skin's surface and transmitting low-energy electrical pulses through the body to induce muscle contraction in the conducting limbs. Commonly, these electrodes are self-adhesive and have to be placed manually, which allows for easy adaptations to specific treatments. However, this procedure is time consuming, error prone, and requires anatomical knowledge of muscle positions [1]. With the development of FES array electrode technologies, these issues can be counteracted. Here a large array of small electrode elements stimulate the muscles, thus, enabling dynamic control of activation regions for improved selectivity and functionality [2]. Due to the a-priori unknown position of the electrodes and individual forms and sizes of muscles in each human, an automatic calibration routines is necessary, in order to preserve the benefits of the array technology. In addition, a mapping between electric stimulation and generated movement or force, may enable the development of FES-based control techniques, which is an open challenge for the upper limb [3]. Especially for more delicate movements in the wrist and hand a precise control strategy is difficult to achieve.
Therefore, the aim of this work is to utilize an array-FES device, marker-based position measurements, and grip force sensors to develop an automatic calibration routine, which maps electrode stimulation to wrist-hand movement and generated torques. Subsequently, based on the learned mapping, different control strategies utilizing FES shall be investigated.

Tasks:

- Literature research on FES and muscle activation models
- Development of an automated calibration routine for electrode activation
- Development and evaluation of a closed-loop controller for wrist-hand movements based on FES

Bibliography:

[1] M. R. Popovic and T. Keller. Modular transcutaneous functional electrical stimulation system. *Medical Engineering & Physics*, 27(1):81 – 92, 2005.
[2] M. Lawrence, G.-P. Gross, M. Lang, A. Kuhn, T. Keller, and M. Morari. Assessment of finger forces and wrist torques for functional grasp using new multichannel textile neuroprostheses. *Artificial Organs*, 32(8):634–638, 2008.
[3] K. Meadmore et al. The application of precisely controlled functional electrical stimulation to the shoulder, elbow and wrist for upper limb stroke rehabilitation: a feasibility study. *Journal of NeuroEngineering and Rehabilitation*, 11(1):105, 2014.

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