Investigation of Bayesian Inversion methods for an electrophysiological skeletal muscle model

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The understanding of muscle movement and interaction in the human body is essential for upholding the best possible treatment in medical care. The muscle physiology can be described by an electrophysiological skeletal muscle model.

This complex multi-scale model contains knowledge about the neural input from the brain transferred to the muscle by the neural system, the feedback information to the nervous system provied by sensory organs in the muscle, as well as the control commands for activation adjustments by the nervous system and the mechanical behaviour of the muscle. The underlying mathematical models are based on a complex coupled system of ordinary and partial differential equations.

Additionally the investigation of the interaction between multiple muscles is essential, because muscles work in agonist-antagonist pairs due to the restriction of single skeletal muscle movement to one direction. This allows multidirectional movement of the limbs. These agonist-anatagonist muscle pairs are coupled mechanically by bones, tendons and other structures.

The approach of this poster is tp present the development of a simulation-based optimization framework to identify optimal muscle parameters for the surgical procedure from clinical data. Thereby, we will address the influence of the prestretch of muscles as our presented use-case.

In detail is the goal to set up an inverse solver for the complex coupled muscle simulation environment as forward simulation with methods from Bayesian statistics to address the identification of model parameters under uncertainties and measurement errors during the production of clinical observed data.

The presented Bayesian framework includes methods from Bayesian inference theory for drawing samples from probability distributions with Markov Chain Monte Carlo methods and Bayesian optimization techniques. A simplified muscle model system with similar characteristics as the target simulation, as well as surrogate model to approximate the forward simulation is integrated to prevent the solution of the inverse problem from numerical issues in terms of runtime and complexity.