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Projects

In the past exercises, we developed a two-segment arm model actuated by two Hill-type muscle-tendon units together. Now it is your turn, be creative and think about what great research you can do with your knowledge. In the interdisciplinary spirit of SimTech, we especially encourage you to use your expert knowledge from other research areas to apply it to biomechanics. You can find some ideas for the possible projects in the following:

Implement new controller strategies

Instead of using a simple open-loop or hybrid controller, you could think about other control strategies: Learning the control signals u_i with an Artificial Neural Network, implementing a joint feedback controller, using nonlinear model predictive control, using central pattern generators ...

Extending the model

Extend the model to include more segments, more DoFs and/or more muscles (e.g. also biarticular muscles), or build up a completely different model such as e.g. a standing person with two legs.

Finding EPs for purposeful movement

A trajectory of equilibrium points (EPs) can be set to create purposeful movement such as pointing, walking, hopping, ...

Monte-Carlo Simulation of muscle-specific parameters

When we included the two muscles in the last exercise, we had to exchange some of the muscle-specific parameters: F_{max}, $l_{\mathrm{SEE},0}$, and $l_{\mathrm{CE,opt}}$. Additionally, muscle non-specific parameters have been used in the initialization scripts. These parameters are based on experimentally measured values and therefore contain uncertainties. Control a movement and vary these parameters e.g. using Monte-Carlo methods to estimate the influence and effect of different parameters.

Interaction with the world

We as humans do not live in an isolated world but rather interact with our surrounding environment on a daily basis. You could think about interesting tasks to model that include interaction with the world such as juggling with a ball, point sliding on a wall/surface, throwing a dart, ...

Patient-specific modelling

The model that was used in the tutorials represents a generic human. However, in some cases, it is necessary to scale the model (e.g. segment lengths, masses, muscle forces) to represent different humans and see individual differences. One possible project could be to implement a simple scaling routine and a controller which works for all different individual models.

Data-driven simulation

You can e.g. use EMG values taken from literature as an input to drive the simulation.

Notes:

- In groups of two: Submit the (modified) model/code and your presentation (in text form/powerpoint/ ...) until **5. February 2024, 9 am** via email to *elsa.bunz@imsb.uni-stuttgart.de*. Please also submit a video of your simulation (e.g. task that you modelled) via email to *elsa.bunz@imsb.uni-stuttgart.de*. With this video, we will make a collage of all projects.
- Your group should present the work that you did on the 7th of February during the last lecture (presentation time per group: tba, roughly 8 mins). This will be your exam for part 2 (Schmitt)! Therefore, of course all group members need to be present!
- You are not limited to the ideas above, you can also do any combination of the ideas above or think of something else as long as it is in the research area of simulation and modeling of biomechanical systems.

Evaluation criteria:

- Motivation or potential research question that can be answered with this project
- Theory slide with explanation of at least one element (e.g. how is contact modeled, how is the control set up, how are joints modeled, ...)
- Did you use any biological concepts / principles and if yes, which? If not, which could be included?
- Presentation of your project (clarity, slides, organization, knowledge)
- Complexity of project
- Creativity of project
- Bonus for including elements that were not used in lecture or exercises (e.g. contact modeling, different simulation environment, using experimental data, new control concepts, ...)