Topic: Development of a Magnetic Resonance Imaging Protocol to Extract Musculoskeletal Parameters

Personalized simulations of gait aim to simulate gait of a specific person. Currently, these simulations are generic (e.g. [1]), and therefore it is not possible to distinguish between persons, and e.g. find an optimal prosthesis for a specific person. A personalized simulation requires that the musculoskeletal model is as similar as possible to the musculoskeletal system of the person for which the simulation is created. To do so, e.g. the mass, inertial and length parameters of the body segments, as well as different muscle parameters, should be personalized. Previously, it was shown that such personalized models improve accuracy during experimental data processing [2]

However, measuring these parameters, especially muscle parameters, in living humans is challenging. One promising approach is to use diffusion tensor imagining (DTI) [3], a type of magnetic resonance imaging (MRI), where diffusion parameters can be used to extract the direction of muscles, which is necessary for accurate extraction of the required muscle parameters. Furthermore, the volume of bone, muscle, fat, and other soft tissue, as measured in an MRI scan, can be used to determine the mass and inertial parameters. Previously, this method has been used to extract muscle parameters of the leg [4]. It is our goal to investigate if a musculoskeletal model with personalized length, weight, and muscle parameters can create personalized simulations of gait.

Therefore, this thesis aims to investigate different measurement approaches for the DTI/MRI measurements. To this end, different protocols will be tested and compared to find which one can best be used to extract musculoskeletal parameters.

The proposed work consists of the following parts:

- Literature study into different measurement protocols
- Selection of protocols to be tested
- Designing and performing of experiment
- Analysis and comparison of different protocols

The thesis must contain a detailed description of all developed and used algorithms as well as a profound result evaluation and discussion. The implemented code has to be documented and provided.

Advisors: Namra Rauf, MSc., Christoph Stuprich MSc., PD. Dr. Sebastian Bickelhaupt, Prof. Dr. Anne Koelewijn, Prof. Dr. Frederik Laun
Student:
Start – End:

References

[1] Koelewijn, A. and Van den Bogert, A. J..: *Joint contact forces can be reduced by improving joint moment symmetry in below-knee amputee gait simulations.* Gait & Posture, 2016.

[2] Charles, J. P., Grant, B., D'Août, K., & Bates, K. T.: *Subject-specific muscle properties from diffusion tensor imaging significantly improve the accuracy of musculoskeletal models.*Journal of anatomy, 2020.

[3] Stieltjes, B., Brunner, R. M., Fritzsche, K., & Laun, F.: *Diffusion tensor imaging: introduction and atlas.* Springer Science & Business Media, 2013.

[4] Charles, J. P., Felipe S., and W. J. Anderst.: *In vivo human lower limb muscle architecture dataset obtained using diffusion tensor imaging.* PloS one 14.10, 2019.