

Topic Areas:

Legged Locomotion, Biomechanics

Modelling, Optimization

Advisor:

Maximilian Raff, raff@iams.uni-stuttgart.de

Responsible Professor:

Prof. C. David Remy

External Partners:

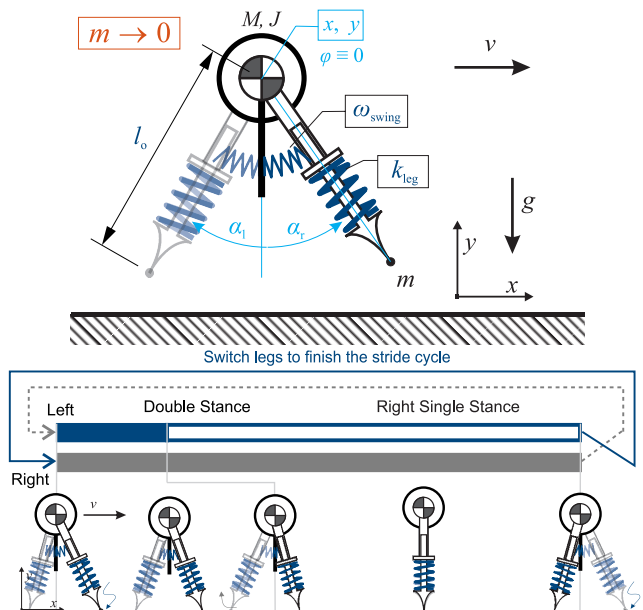
Prof. Tom Buurke, Prof. Han Houdijk

University of Groningen

Prerequisites/Prior Knowledge:

Technical Mechanics III (Dynamics), Matlab,  
(ideally) Dynamics of Legged Locomotion

In this project, we will study a simple mechanical model to better understand the dynamics that underlie human walking. This model consists of a point mass on top of two elastic legs. The mass of the feet is assumed to be vanishing small, and leg swing is aided by a torsional spring that is mounted between the two legs. Despite its simplicity, this model has a remarkable explanatory power. It can exhibit passive periodic motions that qualitatively resemble walking, running, skipping, hopping, and other bipedal gaits. These motions are found along one-dimensional solution manifolds in the space of initial states and can be identified efficiently using numerical continuation techniques [1].



Model used in this project and a periodic walking motion; – one of the many gaits it exhibits [1]

The goal of the project is to perform a quantitative comparison of the motion of this model against data from human walking at different speeds. In this process, you will identify the model's leg stiffness  $k_{leg}$  and hip spring frequency  $\omega_{swing}$  at different walking speeds.

Your task is to implement the model and the necessary techniques for identifying and continuing periodic motions. Furthermore, you will develop metrics and methods to automatically compare the motion and ground reaction forces of the model to those recorded in human subject experiments. Based on these metrics, you will then optimize the model's parameters to maximize agreement of model prediction and experiment. The process is similar to the one described in [2].

The project is carried out in collaboration with partners from the University of Groningen who are experts in human biomechanics. They provide data from human-subject experiments and will assist with the interpretation of the results.

- [1] Gan, Z., Yesilevskiy, Y., Zaytsev, P. and Remy, C.D. *All common bipedal gaits emerge from a single passive model*. Journal of The Royal Society Interface, 2018.
- [2] Gan, Z., Wiestner, T., Weishaupt, M.A., Waldern, N.M. and David Remy, C. *Passive dynamics explain quadrupedal walking, trotting, and tölting*. Journal of computational and nonlinear dynamics, 2016.