University of Stuttgart

Institute for Nonlinear Mechanics

Master's thesis
Term paper

Investigating the Dynamics of Slow Walking

Topic Areas:	Legged Locomotion, Biomechanics Modelling, Optimization
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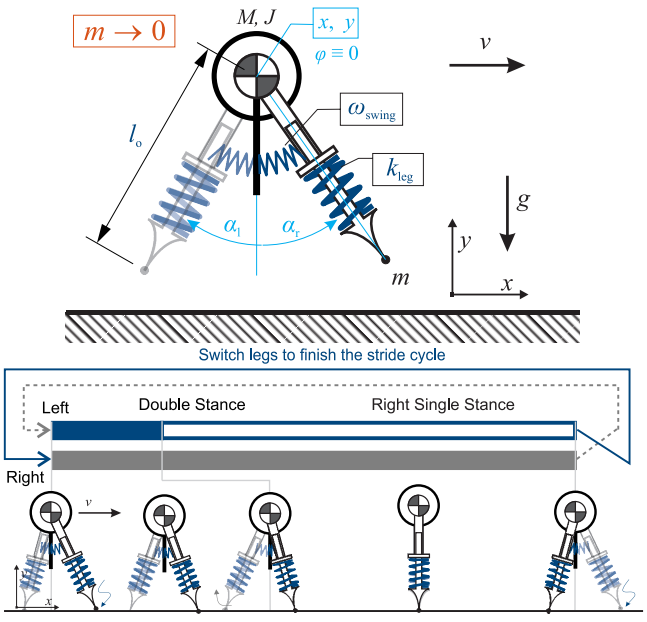
Responsible Professor:	Prof. C. David Remy
External Partners:	Prof. Tom Buurke, Prof. Han Houdijk University of Groningen
Prerequisites/Prior Knowledge:	Technical Mechanics III (Dynamics), Matlab, (ideally) Dynamcis of Legged Locomotion

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 it's 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. In this process, we will put a particular focus on locomotion at very slow walking speeds, as it can be observed in the locomotion of elderly people. Here, the scientific goal is to understand whether the same dynamics are at play at these slow locomotion speeds; – an open scientific question.

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 performed in collaboration with partners at the University of Groningen who are experts in human biomechanics. They provide the data from human subject experiments and will aide 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.