## Topic: Understanding movement decisions in gait using inverse optimal control

Humans can perform tasks in many different ways. For example, to go from A to B, they could walk, run, skip, or hop. However, humans choose to walk at a low speed and run at a high speed very consistently. If we understand the mechanism that chooses the way a task is performed, we can make accurate predictions of human movements, which could aid the design of running shoes, prosthetic legs, and other walking aids.

This mechanism is related to energy efficiency. Gait parameters, such as the step rate, are chosen to minimize energy expenditure [1], and people even change their movement if a different step rate is optimal [2]. However, in other movements, such as bicycling, effort, which is related to the muscle activation, is minimized [3]. Recently, an experiment also pointed out that effort minimization might also be the determining factor in choosing gait, instead of energy expenditure. These two objective have not been compared before. Furthermore, other objectives, such as stability, and cosmetics, might also be important.

Therefore, we aim to investigate what objectives are important in choosing the movement pattern in gait. Inverse optimal control is a tool that allows us to evaluate different objectives [4]. Specifically, the goal is to compare the objective of minimizing effort to the objective of minimizing energy expenditure. A data set of gait at different speeds and slopes is available. The goal of this project is to implement an inverse optimal control approach to find an objective that can predict walking at these different speeds and slopes. An existing software package for gait simulations will be extended to allow for inverse optimal control.

The proposed work consists of the following parts:

- Literature review of inverse optimal control, specifically to gait applications.
- Implementation of inverse optimal control algorithm in existing gait simulation software
- Design of experiment to find and validate objective of gait
- Calculation and analysis of objective using experimental result

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:** Prof. Dr. Anne Koelewijn
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**Start – End:**

# References

[1] Zarrugh, Mohamed et al.: *Optimization of energy expenditure during level walking.* European journal of applied physiology and occupational physiology, 1974.
[2] Selinger, Jessica et al.: *Humans can continuously optimize energetic cost during walking.* Current Biology, 2015.
[3] Ansley, Les and Cangley, Patrick: *Determinants of optimal cadence during cycling.* European journal of sport science, 2009.
[4] Clever, Debora and Mombaur, Katja: *Inverse optimal control as a tool to understand human movement.* In Geometric and Numerical Foundations of Movements, 2017.