Variable Impedance Control of Legged Systems

Short description

Biological legged systems show an astonishing performance in terms of stability, energy efficiency and robustness. They use compliant actuation principles to reject disturbances while increasing energy efficiency. Additionally, large part of the actuation is pure feed forward muscle activation with minor feedback stabilization. Classical robotic systems, on the other hand, use high control gains to accurately follow pre-determined trajectories, which ends up in sacrificing efficiency and stability.

A promising method to overcome these deficiencies is biological motor control. To this end, joints stiffness and damping are modulated over time depending on the task by varying proportional (P) and derivative (D) gains in a PD controller – also known as gain scheduling in robotics. However, finding an appropriate gain schedule for a given task is a very difficult problem to solve. One possible method is reinforcement learning (RL). By accumulating experience in hopping, robotic systems can constantly improve the underlying gain scheduling policy.

In this project, you will model a simple legged robotic system in MATLAB and find the optimal gain scheduling policy using RL. The simulation data from the found policy will be compared to the experimental results of human and other legged mammal locomotion.

Type: Bachelor thesis, Semester project

Partner

Time period: Autumn term, 4 months

Student(s)

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External supervisor(s)

Key words

Biomechanics, Legged locomotion control, Variable impedance control

Context

The goal of this project is to study bio-inspired control scheme and find an efficient control policy using reinforcement learning. Both the control scheme and the optimization method are bio-inspired and, therefore, we want to answer some unsolved problems in biomechanics as well. You will learn robotic reinforcement learning techniques as well as control method of legged robotic systems.

Work packages

- Studying experimental work performed by other researchers (biomechanics) and analyzing their methods and results
- Developing simulation frame work for a simplified planar leg model in MATLAB
- Getting familiar with the robotic learning algorithms and black-box optimization techniques
- Optimizing controller parameters in simulation and comparing the characteristics of the controller with those of the biological systems

Required skills

- MATLAB
- Dynamics system modeling
- Basic knowledge in related fields of mathematics