Physically Consistent Model Learning of Robotic Systems with Gaussian Processes

TECHNISCHE UNIVERSITÄT DARMSTADT

Proposal for a Master's Thesis Project

Nowadays, robotic systems are widely used in a huge variety of applications ranging from industrial manufacturing to robot-assisted surgery to assistance and rehabilitation of disabled humans. In all of these tasks, safe operation of the robotic systems is crucial. To this end, model-based control approaches are usually employed. Although such approaches provide a high level of safety guarantees, they stand and fall with the availability of high-quality system models. As robotic systems are in general Euler-Lagrange systems, their models are derived from employing the Lagrangian framework to describe the equations of motion. Unknown kinematic parameters of the system are usually estimated from data using standard least-squares regression techniques. Hence, the obtained models are in general subject to parametric uncertainty, which deteriorates the performance of the closed-loop system.

Recently, it has been shown that the model quality significantly benefits from employing Gaussian process regression, a statistical machine learning approach, in the Lagrangian framework. Instead of deriving a parametric, physics-driven model, the potential and kinetic energies contributing to the system's Lagrangian are learned directly from data. To this end, the approach uses highly specialized Gaussian process models that induce a physically consistent model structure. Hence, the plausibility and interpretability of the learned model are improved when compared to standard learning approaches. Within the scope of this thesis, the proposed approach is to be implemented, tested and validated against standard approaches. The implementation shall enable reusability and embedding in larger code frameworks. Appropriate implementation techniques are to be researched and used.

The following prerequisites will be useful for the project:

Experience with / knowledge about:	Gaussian process regression, Robotics, Lagrangian mechanics, Dynamical Systems
Programming skills:	Python
Language:	German or English

M.Sc. Maik Pfefferkorn
E-Mail: maik.pfefferkorn@ovgu.de
Tel.: 0391 / 67 52212

M.Sc. Philipp Holzmann
E-Mail: philipp.holzmann@iat.tu-darmstadt.de
Tel.: 06151 / 16 25189

CCPS Control and Cyber-Physical Systems