ICS
Institute of Control Systems

Master's thesis **M — 7 — 2020**
for Mr. Yashasvi Sai Sukhavasi Student ID: 21757720 Study Course: IMPMEC

Title:
Comparison of data-driven control algorithms using Koopman operator and LPV techniques for evaluating the tracking performance of an Arm-Driven Inverted Pendulum

Project Description:
The Koopman operator theory [1], is an increasingly popular formalism of dynamical systems theory that enables analysis, prediction and control of nonlinear dynamics from measurement data. Such data-driven techniques allow for devising linear control strategies for highly nonlinear dynamical systems for which first principle models are not available or are impractical to be constructed.

The motivation for this Master's thesis is derived from the desire to generate dynamical models of an ADIP through measured data. In particular it is of interest to synthesize linear model-based controllers using these data-driven models in simulation and experimentally compare the performance of data-driven controllers with LPV contrrollers based on first principles in tracking a reference trajectory.

Tasks:

1. Literature review of state-of-the-art architecture for data-driven control systems
2. Develop a data-driven approach using Koopman operator theory for constructing a linear representation of the ADIP plant for the purpose of swing-up and stabilizing control
3. Synthesize a quasi-LPV controller governing the swing-up dynamics and a stabilizing Linear Quadratic Regulator and a stabilizing quasi-LPV controller for the aforementioned data-driven model
4. Simulate and compare the performance of the derived controllers in tracking a reference trajectory
5. Experimentally validate the simulation results
6. Optional: Extend the above framework to synthesizing a stabilizing data-driven quasi-LPV Predictive Controller using Koopman operator techniques(KqLMPC) and compare it with the existing results on the performance of qLMPC control strategy applied on the model obtained from first principles, [2].

References:

[1] B. O. Koopman, "Hamiltonian systems and transformation in hilbert space", *Proceedings of the National Academy of Sciences*, vol. 17, no. 5, pp. 315–318, May 1931. DOI: 10.1073/pnas.17.5.315. [Online]. Available: https://doi.org/10.1073%2Fpnas.17.5.315.

[2] P. Cisneros and H. Werner, "Wide range stabilization of a pendubot using quasi-lpv predictive control", *IFAC-PapersOnLine*, vol. 52, pp. 164–169, Jan. 2019. DOI: 10.1016/j.ifacol.2019.12.367.

Supervisor: Patrick Göttsch, M.Sc.
Examiner: 1. Prof. Dr. Herbert Werner
2. Prof. Dr. Tobias Knopp

Deutscher Titel: Vergleich von datengetriebenen Regelungsalgorithmen basierend auf dem Koopman Operator und LPV-Techniken zur Evaluation der Tracking-Performance eines armgetriebenen invertierten Pendels

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Due Date: 15.12.2020

26.06.2020, Prof. Dr. H. Werner