Institute of Mechanics and Fluid Dynamics
Chair of Applied Mechanics – Dynamics

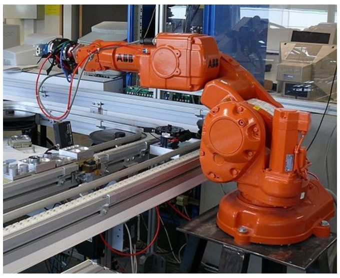
Announcement: Master Thesis

Koopman Eigenfunctions of a Double Pendulum for Global System Linearization

For the mathematical description of dynamic (mechanical) systems, systems of ordinary differential equations of the form $\dot{\mathbf{x}} = \mathbf{f}(\mathbf{x}, t)$ are usually used, where the state vector $\mathbf{x}$ contains the position and velocity coordinates of the system. The motion of such a system – i.e. the solution $\mathbf{x}(t)$ for given initial conditions $\mathbf{x}(0) = \mathbf{x}_0$ – can usually only be approximated by numerical simulation, as the majority of models of practical interest are non-linear. The computational time required to solve the system model numerically is a major limitation for model-based control approaches such as MPC, where the system behavior must be predicted by simulation for a certain time *in real time* – i.e. in a given, very short time.

In the past approx. 15 years, a lot of research has been done on Koopman operator theory within the dynamics community. This enables alternative system modeling, whereby the system models are usually *linear* or *bilinear* and thus much easier to solve. Koopman operator theory is the basis of many data-based methods such as DMD, EDMD, Sindy, etc. So-called Koopman eigenfunctions can be used to systematically determine or approximate a coordinate transformation that linearizes the system globally. This is very attractive as a basis for real-time control, e. g. in robotics applications.

In 2024, M. Breitenhuber implemented and investigated a methodical approach to globally linearize a simple pendulum in a bachelor thesis at KIT (see `doi.org/10.1002/pamm.202400187`). In this thesis, the approach is to be transferred to a double pendulum in order to show whether/that this is possible for multiple pendulum systems such as the robot arm shown as an example.



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