University of Stuttgart

Institute for Nonlinear Mechanics

Master's thesis

Invariant Cones of an Automative Brake System

Topic Areas:	Model Order Reduction, Simulation Piecewise Linear Dynamical Systems
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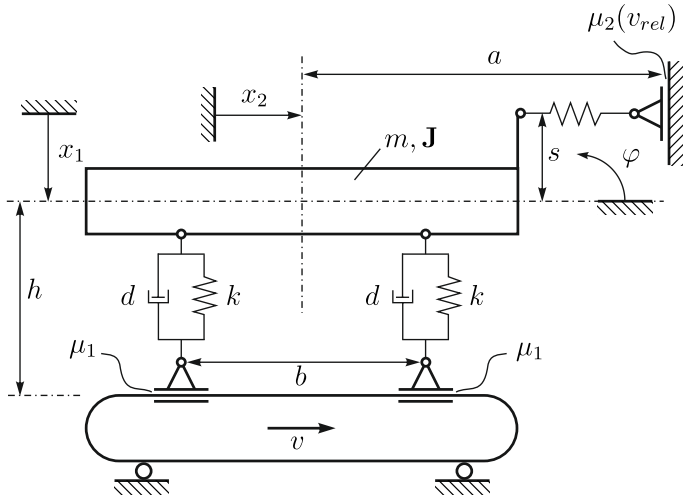
Prerequisites/Prior Knowledge:	Nonlinear Dynamics, Matlab

The concept of invariant manifolds is central to the study of dynamical systems, since they can be used to reduce high-order systems to lower-dimensional objects. This allows to carry out a computationally efficient stability and bifurcation analysis of the original dynamics by studying its corresponding low-order approximation. In the traditional approach, the reduction to invariant manifolds requires smoothness properties of the dynamical system. Recently, important efforts have been made to extend such a reduction method to a class of nonsmooth systems, for which the existence of invariant sets have also been established. For piecewise linear systems, these invariant objects appear as the surface of invariant cones, on which the dynamics of the full system can be reduced to a two-dimensional object [1].

In this master thesis project, you will investigate the reduction of a 6-dimensional automotive brake system to its invariant cones. To start this quest, you will learn the theoretical principles of this model reduction method. Then, you will implement a computational method, e.g. the bordering algorithm, in order to compute the invariant cones of simple 3-dimensional piecewise linear systems. This serves as a bridge towards the investigation of the 6-dimensional brake system. Once the generation of cones for this specific case is well-understood, you will be encouraged to extend the approach to include similar nonsmooth nonlinearities and eventually consider piecewise nonlinear systems. The case of harmonically excited piecewise linear systems may also be investigated.



Three DOF brake system

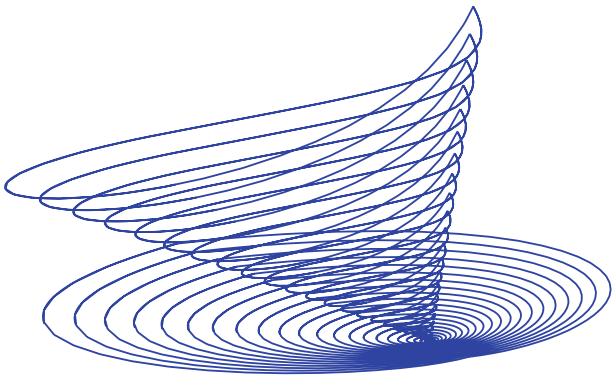


Illustration of invariant cones in state space

[1] H. Hosham (PhD thesis) - *Cone-like Invariant Manifolds for Nonsmooth Systems*, 2011