Data-driven control of nonlinear systems with guarantees using polynomial interpolation

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This poster deals with the controller design for nonlinear dynamical systems for which no mathematical model but measured trajectories are available. Typically, the determination of a controller requires the knowledge of a model of the underlying system for which an identification by first principles is mostly time-consuming and calls for expert knowledge. At the same time, many data-driven approaches for nonlinear systems lack of rigorous guarantees, call for nonconvex optimization, or require knowledge on the true basis functions of the unknown systems dynamics. To circumvent these issues, we introduce in [1] a representations of nonlinear systems which is based on polynomial approximation techniques and can be derived from noisy input-state data. By incorporating the error of polynomial approximation, various deterministic or Gaussian noise characterizations, and potentially given prior knowledge on the structure of the system dynamics, we provide a procedure in [2] to derive a state-feedback controller that globally stabilizes the underlying unknown system and satisfies closed-loop performance guarantees. Due to the polynomial representation of the system dynamics and exploiting sum-of-squares relaxation, the controller synthesis boils to a semi-definite programming which is convex and hence tractable. Furthermore, our method is illustrated in numerical examples.

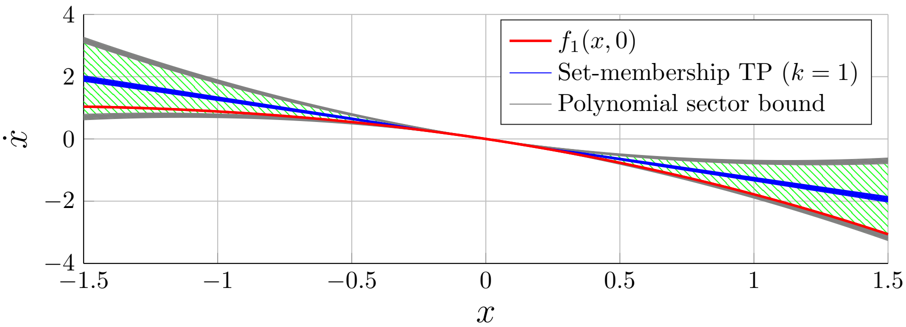

Figure 1: Data-driven envelope (green area) of an unknown nonlinear function $f_1(x, 0)$ using 1-st order Taylor polynomial. The illustration is taken from [1].

References

[1] T. Martin and F. Allgöwer. Determining dissipativity for nonlinear systems from noisy data using Taylor polynomial approximation. In Proc. American Control Conf. (ACC),

pp. 1432-1437, 2022.

[2] T. Martin, T. B. Schön, and F. Allgöwer. Gaussian inference for data-driven state-feedback design of nonlinear systems. Preprint: arXiv:2211.05639, 2022.