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# Direct feedback control design for nonlinear systems

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Abstract - We propose an approach for the direct design from data of controllers finalized at solving tracking problems for nonlinear systems. This approach, called Direct FeedbacK (DFK) design, overcomes relevant problems typical of the standard design methods, such as modeling errors, non-trivial parameter identification, non-convex optimization, and difficulty in nonlinear control design. Considering a Set Membership (SM) approach, we provide three main contributions. The first one is a theoretical framework for the stability analysis of nonlinear feedback control systems, in which the controller $\hat{f}$ is an approximation identified from data of an ideal inverse model $f_0$. In this framework, we derive sufficient conditions under which $\hat{f}$ stabilizes the closed-loop system. The second contribution is a technique for the direct design of an approximate controller $f^*$ from data, having suitable optimality, stability, and sparsity properties. In particular, we show that $f^*$ is an almost-optimal controller (in a worst-case sense), and we derive a guaranteed accuracy bound, which can be used to quantify the performance level of the DFK control system. We also show that, when the number of data used for control design tends to infinity and these data are dense in the controller domain, the closed-loop stability is guaranteed for a set of trajectories of interest. The technique is based on convex optimization and sparse identification methods, and thus avoids the problem of local minima and allows an efficient online controller implementation in real-world applications. The third contribution is a simulation study, regarding the application of DFK to the challenging problem of control design for a class of airborne wind energy generators.