The framework of input-to-state stability with application to interconnected systems

Sergey Dashkovskiy

University of Würzburg, Würzburg, Germany

email: sergey.dashkovskiy@uni-wuerzburg.de

The notion of input-to-state stability (ISS) was introduced in [1] for nonlinear finite dimensional systems of the form

$$\dot{x} = f(x,d), \quad x(t) \in \mathbb{R}^n, \quad d(t) \in \mathbb{R}^m, \quad t \geq 0, \tag{1}$$

with an unknown disturbance $d \in L_\infty^{loc}$. This notion extend the usual Lyapunov stability to the case of systems with input signals. Several weaker versions of this notion appeared soon after that in the literature together with different characterizations of these notions. Later these notions were extended to other classes of systems, including discrete time systems, switched, impulsive and hybrid systems, systems with time delay as well as systems given in form of partial differential equations, see [2], [3].

This presentation we begin with an introduction to ISS and related notions illustrated by means of simple practical examples. Characterizations of these notions, in particular by means of Lyapunov functions, will be provided and illustrated as well. We will show that this framework is very fruitful for stability investigation of nonlinear networks. We will explain how the small-gain theory in the ISS framework can be applied to study stability of interconnected systems, including large scale multi-agent systems.

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References

[1] Sontag, E.D. . Smooth stabilization implies coprime factorization. *IEEE Trans. Automat. Control*, 34 (1989), no. 4, 435–443; doi: 10.1109/9.28018

[2] Dashkovskiy, Sergey and Kosmykov, Michael and Mironchenko, Andrii and Naujok, Lars. Stability of interconnected impulsive systems with and without time delays, using Lyapunov methods. *Nonlinear Analysis: Hybrid Systems*, 6 (2012), no. 3, 899–915; doi.org/10.1016/j.nahs.2012.02.001

[3] S. Dashkovskiy, and A. Mironchenko. Input-to-state stability of infinite-dimensional control systems. *Math. Contr. Sign. Syst.*, 25 (2013), no. 1, 1–35; doi 10.1007/s00498-012-0090-2