FLORIDA ATLANTIC UNIVERSITY

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PhD Dissertation Defense

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Integral Input-to-Output Stability Analysis for Nonlinear Systems with Time Delays

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One of the central issues in stability analysis for control systems is how robust a stability property is when external disturbances are presented. This is even more critical when a system is affected by time delay. Systems affected by time delays are ubiquitous in applications.

Time delays add more challenges to the task of stability analysis, mainly due to the fact that the state space of a delay system is not a finite-dimensional Euclidean space anymore, but rather an infinite dimensional space of continuous functions defined on the delay interval.

In this work, we investigate robust output stability properties for nonlinear systems affected by time delays and external disturbances. Frequently in applications, the requirement of stability properties imposed on the full set of state variables can be too strenuous or even unrealistic. This motivates one to consider robust output stability properties which are related to partial stability analysis in the classic literature.

We start by formulating several notions on integral input-to-output stability and illustrate how these notions are related. We then continue to develop Lyapunov-Krasovskii type of results for such stability properties. As in the other context of Lyapunov stability analysis such as global asymptotic stability and input-to-state stability, a Lyapunov-Krasovskii functional is required to have a decay rate proportional to the magnitudes of the state variables or output variables on the whole delayed interval. This is a difficult feature when trying to construct a Lyapunov-Krasovskii functional. For this issue, we turn our efforts to Lyapunov-Krasovskii functional with a decay rate depending only on the current values of state variables or output variables. Our results lead to a type of Lyapunov-Krasovskii functionals that are more flexible regarding the decay rate, thereby leading to more efficient results for applications.

Finally, we explore the robust stability properties for delay systems parameterized by a small parameter. For such systems, the length of the delay interval reduces to zero as the parameter approaches zero. In this sense, the perturbation caused by the parameter becomes a singular perturbation. Our main task is to study how the integral input-to-state stability for the zero-perturbed system can be preserved for the system under small perturbation.

Please contact Dr. Hongwei Long (hlong@fau.edu) for an electronic copy of the dissertation.
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