Offline and Online Use of Interval Analysis for the Design and Implementation of Robust Control and State Estimation Strategies

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Over the last decades, interval analysis has become a well established tool for the computation with continua of real- and complex-valued variables. In combination with functionalities for directed rounding, it is possible to implement approaches that are executed on a computer using finite precision arithmetic (e.g., using double-precision floating point numbers) with which tasks such as the evaluation of algebraic functions that include bounded uncertainty in selected parameters, global optimization, guaranteed root finding for sets of algebraic equations, or the simulation of initial value problems for sets of ordinary differential equations can be solved. In comparison with classical floating point numerics, interval methods possess the advantage that the exact results of the corresponding mathematical problem formulations are never missed and that they are guaranteed to be contained in the output intervals that are produced by the corresponding algorithms. From that point of view, these methods are commonly characterized as being *verified*.

As a state-of-the-art, even for engineering applications, these techniques are typically employed offline during stages of system design and verification. This presentation gives an overview of recent advances allowing for the use of interval methods in the frame of designing, optimizing, and implementing robust control and state estimation approaches. The focus of this talk is especially the online use of interval methods in real-time environments that allows, among others, for parameter adaptation strategies of nonlinear controllers for which interfacing these verified methods with Lyapunov function techniques ensures a guaranteed proof of asymptotic stability despite the omnipresent influence of parameter uncertainty and external disturbances which are both assumed to represented in a bounded-error framework. Selected experimental results for the control of mechanical systems as well as applications from the energy domain conclude this talk.