Stability of Hybrid Systems using Sum of Squares (SoS) Programming Approach: VCCR System Example

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Hybrid dynamic models describe hierarchical processes, which evolve according to different sets of lower level dynamic components depending on the upper level logical/discrete mode that characterizes the system, at any given point in time. In general hybrid systems consist of a finite set of modes of operation described in continuous time with differential equations. Continuous modes of operation are interfaced with some logical or decision−making process.

Recently the Sum of squares (SoS) programming approach for system stability analysis has been introduced in [1]. A general description of the SOSTOOLS tool with formulation details can be found in [3]. SoS approach is based on well−established semi−definite programming surveyed in [2]. In semi−definite programming a linear function is minimized subject to the constraint that an affine combination of symmetric matrices is positive semi−definite. Such a constraint is nonlinear and non−smooth, but convex, so positive definite programs are convex optimization problems. It is believed that SoS approach can be used for hybrid system stability analysis, too [4].

We would like to focus on using SOSTOOLS to perform stability analysis of the Variable Configuration CO_2 Removal (VCCR) system, that is part of an overall Air Revitalization System for life support in space [5]. Its basic function is to recover CO_2 from the crew cabin by adsorption into an absorber. Accumulated CO_2 is desorbed and sent to an accumulator for recovery of O_2. The two absorber beds act like containers into which CO_2 from the cabin can be accumulated at a certain rate, while in the adsorption mode. Similarly, the two beds can be drained of their CO_2 content, while in the desorbtion mode. We would like to develop a simplified model of the VCCR system to simulate both the normal and off−spec operating conditions, and to use SOSTOOL to perform an initial stability analysis of the VCCR system.

References

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