64g A Global Optimization Approach to the Design of Stabilizing Controllers

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Stabilizability is a primary objective in the design and operation of process systems. As a result, the problem of designing stabilizing controllers has received considerable attention in the literature of control system design. The eigenvalue optimization approach maximizes the stability margin and has been traditionally applied to design robust stabilizing controllers. However, there still exist various instances of stabilizing controller design problems that cannot be solved by a simple application of this traditional approach.

In this work, we take different perspective to achieve stability. Instead of maximizing the stability margin, we require the resulting design to be stable with pre-specified degree of robustness, while optimizing the productivity of the underlying process system. Algebraic methods for stability, including mathematical results on the roots of polynomials and matrix eigenvalues, are employed in our approach. Their mathematical formulations and rigorous solution algorithms are developed in this work and various theoretical and numerical aspects are discussed.

As a concrete example, we consider the Belgian chocolate stabilization problem, a representative from this difficult class of controller design problems that remains still open since it was posed in 1994 [1]. We develop a solution strategy to solve this nonsmooth and nonconvex bilevel optimization problem to global optimality. Key to our approach is the elimination of the second-level problem by incorporating suitable stability constraints in the first-level problem. We then rely on the recently developed branch-and-reduce global optimization algorithm [2] to solve the resulting optimization problem to global optimality. We present extensive computational results, including new stabilizing controllers for the Belgian chocolate stabilization problem that improve the best known solutions for this problem.

References:

[1] Blondel, V., Simultaneous stabilization of linear systems, Lecture Notes in Control and Information Sciences 191, Springer, Berlin, 1994.

[2] Tawarmalani, M. and N. V. Sahinidis, Global optimization of mixed-integer nonlinear programs: A theoretical and computational study, Mathematical Programming, Ser. A, 99(3), 563-591, 2004.