論文の内容の要旨

A Region-Dividing Approach to Robust Semidefinite Program and Nonlinear Control Design

(ロバスト半正定値計画および非線形制御系設計のための領域分割型アプローチ)

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Robust semidefinite programs (robust SDPs in short), which cover a wide range of applications in control, are considered in this thesis. We first provide a novel approach to a certain class of robust SDPs, whose decision variable is a finite-dimensional vector. Construction of an approximate problem to a given robust SDP is based on the sum-of-squares (SOS) approach. Unlike the conventional use of the SOS approach, however, the quality of approximation is improved by dividing the parameter region into several subregions. We prove that the optimal value of the approximate problem converges to that of the original problem as the resolution of the division becomes higher. The convergence result is {¥em quantitative} in the sense that an {¥em a priori} upper bound on the approximation error is available in terms of the resolution of the division. This bound shows a trade-off between the approximation error and the resolution of the division. The current approach can be straightforwardly extended to robust SDPs with a decision variable dependent on an uncertain parameter.
We also provide a numerically tractable condition to verify when an approximate problem involves no conservatism. This condition is obtained by observation on some structure of a dual feasible solution of the approximate problem.

An application of robust SDPs to nonlinear optimal control is also considered. We solve Hamilton-Jacobi-Bellman inequalities in order to find an upper bound and a lower bound on the optimal performance. The key idea is to represent a given nonlinear system into a special representation called a *linear-like form*. Based on this representation, searching for polynomial solutions of the Hamilton-Jacobi-Bellman inequalities can be cast as robust SDPs, which can be solved by the SOS approach. Improvement on the bounds can be done by increasing the degrees of the polynomial solutions. Stabilizing controllers can also be obtained from the solutions of the resulting robust SDPs.