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Optimal Ellipsoid Approximations in Control Theory

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Abstract: A Minimum volume ellipsoids containing a given set arise often in control theory observed as a problem that solves differential equation with inputs and outputs. Generally, the problem is described by a differential inclusion $\dot x\in F(x(t),t)$, where F is a set valued function on $\mathbb{R}^n\times \mathbb{R}_+$. An ellipsoid is given itself with a symmetric, positive definite matrix Q such that $\mathcal{E}=\{\xi\in\mathbb{R}^n, (\xi-\xi_0)^TQ^{-1}(\xi-\xi_0)\leq 1\}$.

If a linear differential inclusion is given by $\dot x\in \Omega x$, $x(0)=x_0$, and with $\Omega\subseteq\mathbb{R}^{n\times n}$, then sufficient condition for the system stability is to find a positive definite symmetric matrix P such that the quadratic function $V(\xi)=\xi^TP\xi$ decreases along every nonzero state trajectory.

Specific linear differential inclusions are described, such as the linear time-invariant, Polytopic, norm-bound with additional output that affects the additional input in bounded measure or diagonal norm-bound bounds of input and output functions are given componentwise.

In our work we interpreted stability conditions of above systems in terms of ellipsoid that is invariant to a solution of a differential inclusions: if $x(t_0)\in\mathcal{E}$ then $x(t)\in\mathcal{E}$ for every $t\geq t_0$.

Keywords: control theory; minmal volume ellipsoid; symmetric matrix; linear matrix inequalities

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