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single variable, constituting the so-called polynomial Lyapunov equation (PLE):  $(1) R( - ) T X( ) + X( - ) T R( ) = Z( )$ . Here  $R( )$ ,  $X( )$  and  $Z( )$  are  $q \times q$  real polynomial matrices in the indeterminate

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The equation  $(sI + A)Y(s) - Q(s) = T^T Q(s)$  (4) in the unknown  $R$ -canonical symmetric two-variable polynomial matrix  $Y \in \mathbb{R}[s, s^{-1}]^{n \times n}$ ;  $Q \in \mathbb{R}[s, s^{-1}]^{n \times n}$  is called the lifted polynomial Lyapunov equation (LPLE). Solvability of the PLE is equivalent to solvability of the LPLE, as the following proposition shows.

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Lyapunov function. In the majority of applications steady flows are better than unsteady flows. Steady flows are usually associated with smaller fuel consumption, less fatigue, and less noise. Theoretically, a steady flow always exists as a solution of the governing equations. However, in engineering applications fluid flows are usually unsteady, or even turbulent, because the corresponding steady flow is unstable, that is, if disturbed it will never return to the steady state.

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associated lifted polynomial Lyapunov equation which lives on a finite-dimensional vector space. This allows for the design of an iterative solution method which A new algorithm to solve the polynomial

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Lyapunov equation require the construction of polynomial Lyapunov functions. The simplest class of polynomial Lyapunov function is the

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First, positive polynomial system is obtained via the local property of the Lyapunov function as well as its derivative. Then, the positive polynomial system is converted into an equation system by adding some variables. Finally, numerical technique is applied to solve the equation system. Some experiments show the efficiency of our new algorithm.

## ~~Constructing the Lyapunov Function through Solving ...~~

Let  $p = p(x)$  be a polynomial of degree  $m \geq 2$ . If  $p(x)$  is positive definite in  $\mathbb{R}^n$ , then for any  $d \geq m + 1$  and every polynomial  $q(x)$  of the form  $q(x) = \sum_{i=m+1}^d q_i(x)$ , where  $q_i(x)$  is either the zero polynomial or a homogeneous polynomial of degree  $i$ , there is a neighborhood  $U$  of the origin such that the sum  $p(x) + q(x)$  is positive definite in  $U$ . Proof

## ~~Discovering polynomial Lyapunov functions for continuous ...~~

Lyapunov functions and obtain an ERA given by the level set of these functions. These methods rely on the solution of non-convex constraints given by polynomial inequalities derived with the Positivstellensatz [8, Theorem 2.14] and require a coordinate-wise search since some polynomial variables appear multiplying the Lyapunov function.

## ~~Region of Attraction Analysis Via Invariant Sets~~

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Furthermore, a Lyapunov function can always be found by finding the positive-definite solution to the matrix Lyapunov equation  $(1) P A + A^T P = -Q$ , for any  $Q = Q^T \geq 0$ . This is a very powerful result - for nonlinear systems it will be potentially difficult to find a Lyapunov function, but for linear systems it is straightforward.

## ~~Underactuated Robotics: Lyapunov Analysis~~

By increasing the degree of the approximating SOS polynomial, we again obtain a hierarchy of SDP problems to compute the desired Lyapunov function. Then, we derive the corresponding algorithms for those two techniques, which can be seen as an adaptation of tools available in the literature on polynomial optimization.

## ~~Cone-Copositive Lyapunov Functions for Complementarity ...~~

The simultaneous Lyapunov sector obtained here is the maximum sector for a certain choice of the Lyapunov matrix equation, or more specifically for an arbitrary positive definite matrix  $Q$  in eq. (27), which means that the thus obtained sector is not necessarily the maximum simultaneous Lyapunov sector for the given nonlinear feedback system. However, it should be emphasized that the ...

## ~~Matrix Lyapunov Equation – an overview | ScienceDirect Topics~~

Recently, a method was proposed by Goulart & Chernyshenko for exploiting the sum-of-squares (SOS) decomposition [7,8] to construct polynomial Lyapunov functionals differing from  $E$ , thus extending the range of  $Re$  in which the flow can be proved to be globally stable. In this approach, the Navier – Stokes equations are first reduced to a finite-dimensional uncertain dynamical system, that is a system of ordinary

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differential equations (ODEs) with right-hand side containing terms for which only ...

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sum of squares programs, whose solution directly provides a stabilizing controller and a Lyapunov function. We then derive variations of this result that lead to more advantageous controller designs. The results also reveal connections to the problem of designing a controller starting from a least-square estimate of the polynomial system. I ...

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