Sparse moment-sum-of-squares relaxations for nonlinear dynamical systems with guaranteed convergence

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We present sparse moment-sum-of-squares approximations which can be applied for three problems from nonlinear dynamical systems : region of attraction, maximum positively invariant set and global attractor. We prove general results allowing for a decomposition of these sets provided that the vector field and constraint set posses certain structure. We combine these decompositions with existing methods based on infinite-dimensional linear programming. For polynomial dynamics, we show that these problems admit a sparse sum-of-squares (SOS) approximation with guaranteed convergence such that the number of variables in the largest SOS multiplier is given by the dimension of the largest subsystem appearing in the decomposition. The dimension of such subsystems depends on the sparse structure of the vector field and the constraint set and can allow for a significant reduction of the size of the semidefinite program (SDP) relaxations, thereby allowing to address far larger problems without compromising convergence guarantees.

Keywords : dynamical systems, semidefinite programming, sparse structures, sum-of-squares

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