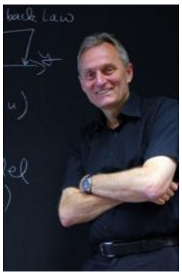

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Balanced Truncation for Bilinear-Quadratic Output Systems

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We study so called bilinear-quadratic output (BQO) systems of the form $\dot{x}(t) = Ax(t) + \sum_{k=1}^{m} N_k x(t) u_k(t) + Bu(t)$ with initial condition $x(0) = 0$ and output $y(t) = Cx(t) + \begin{bmatrix} x(t)^T M_1 x(t) & \dots & x(t)^T M_p x(t) \end{bmatrix}^T$, where $A \in \mathbb{R}^{n \times n}, B \in \mathbb{R}^{n \times m}, C \in \mathbb{R}^{p \times n}, N_k \in \mathbb{R}^{n \times n}$ for $k = 1, \dots, m$, $M_j \in \mathbb{R}^{n \times n}$ for $j = 1, \dots, p$, $t \in [0, \infty)$. Here, $x(t) \in \mathbb{R}^n$ describes the state, $u(t) \in \mathbb{R}^m$ the input and $y(t) \in \mathbb{R}^p$ the output of the system. Moreover, we assume M_j to be symmetric due to $x(t)^T M_j x(t) = x(t)^T M_j^T x(t) = \frac{1}{2} x(t)^T (M_j + M_j^T) x(t)$.

We present algebraic Gramians in different variants for these BQO systems, compare them and their relations to Lyapunov equations arising from bilinear ($M_j = 0$) or linear-quadratic output ($N_k = 0$) systems. Next, we propose a balancing algorithm for truncation of certain states with the goal of structure-preserving model order reduction. This algorithm is tested in several numerical experiments.

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