Quadrature-based balancing and some recent developments

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Balanced truncation (BT) and its variants are among the "gold standards" for projection-based model reduction of dynamical systems. This is because it preserves important system-theoretic features of the full-order model (FOM) and satisfies tractable bounds on the approximation error. The system Gramians are the key components of any balancing-based model reduction algorithm. In classical BT, the Gramians are the unique solutions to dual algebraic Lyapunov equations. Balancing is the simultaneous diagonalization of two such matrices. Once these two matrices are computed, one balances the FOM by an appropriate change of coordinate system in which the Gramians are diagonal and identical. The recent work of G./Gugercin/Beattie '22 derives a novel data-driven reformulation of BT, known as quadrature-based balanced truncation or QuadBT. Data measurements are in this case input-output frequency-response data (e.g., particular transfer function measurements) sampled along the imaginary axis. QuadBT works by (implicitly) replacing the exact square-root factors of the Gramians P and Q with approximate quadrature-based factors derived from appropriate integral representations. In this way, QuadBT does not require the computation of approximated Gramians or even their corresponding factors. As it will be shown, one needs to instead compute appropriate Loewner matrices that scale with the number of quadrature nodes and weights employed. If time permits, we show recent extensions of QuadBT to other classes of dynamical systems.