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Efficient iterative solution of nonstandard algebraic Riccati equations via indefinite factorizations

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For the standard algebraic generalized Riccati equation

$C^TQC + A^TXE + E^TXA - E^TXBR^{-1}B^TXE = 0$

different algorithms inspired by the low-rank alternating directions implicit (LR-ADI) iteration and Krylov subspace projection have successfully been applied, based on the ZZ^T factorization of the iterates, when Q, R are both symmetric, and $Q \geq 0$ and $R > 0$.

In this contribution, we investigate the more general equations of the type

$C^TQC + A^TXE + E^TXA - (E^TXB + S)^TR^{-1}(B^TXE + S^T) = 0$

allowing for $R > 0$, $R < 0$ or even indefinite R. While for the specific cases we investigate, the solution is always the stabilizing solution which can be shown to be semi-definite, the latter is not always true for intermediate iterates. Thus, in order to avoid complex arithmetic, and to simplify algorithmic representations, we suggest the use of indefinite factorizations of the form LDL^T for the representation of solution approximations and residuals. The main goal of this research is to bring low-rank Riccati solvers closer to the capabilities of, e.g., `icare` in MATLAB. This, in turn, enables balancing based model order reduction methods, such as positive-real or bounded-real balanced truncation, for large-scale linear time-invariant (LTI) systems.

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