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Recent Advances in the Solution of the Unilateral Quadratic Matrix Equation

Content

The Unilateral Quadratic Matrix Equation (UQME)
\begin{equation}
AX^2+BX+C=0
\end{equation}
is a rarely mentioned equation in numerical linear algebra. Only a few
publications and algorithms cover the solution of this equation. In this talk, we will see some existing solvers, namely the Schur-Method, the Bernoulli-Iteration, the Newton-Methtod, and the Cyclic Reduction. All these solvers have issues that are avoids a general usage. Especially bad or missing convergences is crucial at this point. One approach to get a general purpose solver is to use a spectral divide and conquer scheme to solve the underlying eigenvalue problem
\begin{equation}
Fy = \begin{bmatrix}
0 & I \\ -C & -B
\end{bmatrix}
y = \lambda \begin{bmatrix}
I & 0 \\ 0 & A \end{bmatrix} y = \lambda Gy , \quad y =\begin{bmatrix}
v \\ \lambda v
\end{bmatrix}.
\end{equation}
By computing the generalized Schur decomposition of $(F, G) = Q(T, S)Z^H$ we obtain
\begin{equation}
Z = \begin{bmatrix} Z_{11} & Z_{12} \\ Z_{21} & Z_{22} \end{bmatrix},
\end{equation}
from which the solution X of the UQME can be constructed via
\begin{equation}
X = Z_{21}Z_{11}^{-1}.
\end{equation}
The spectral divide and conquer algorithm successively constructs the matrix Z until Z_{11} and Z_{12} can be extracted. The presentation will describe the new spectral division approach and compares it to the existing ones.

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