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Minimal rank factorizations of general and structured polynomial matrices

Tuesday, September 2, 2025 2:00 PM (30 minutes)

We investigate rank revealing factorizations of $m \times n$ polynomial matrices $P(\lambda)$ into products of three, $P(\lambda) = L(\lambda)E(\lambda)R(\lambda)$, or two, $P(\lambda) = L(\lambda)R(\lambda)$, polynomial matrices. Among all possible factorizations of these types, we focus on those for which $L(\lambda)$ and/or $R(\lambda)$ is a minimal basis, since they have favorable properties from the point of view of data compression and allow us to relate easily the degree of $P(\lambda)$ with some degree properties of the factors. We call these factorizations "minimal rank factorizations". Motivated by the well-known fact that, generically, rank deficient polynomial matrices over the complex field do not have eigenvalues, we pay particular attention to the properties of the minimal rank factorizations of polynomial matrices without eigenvalues. We carefully analyze the degree properties of generic minimal rank factorizations in the set of complex $m \times n$ polynomial matrices with normal rank at most $r < \min\{m, n\}$ and degree at most d, and we prove that there are only $rd + 1$ different classes of generic factorizations according to the degree properties of the factors and that all of them are of the form $L(\lambda)R(\lambda)$, where the degrees of the r columns of $L(\lambda)$ differ at most by one, the degrees of the r rows of $R(\lambda)$ differ at most by one, and, for each $i = 1, \ldots, r$, the sum of the degrees of the ith column of $L(\lambda)$ and of the ith row of $R(\lambda)$ is equal to d. Finally, we study structured versions of these factorizations in the case of symmetric, Hermitian, skew-symmetric, and skew-Hermitian polynomial matrices.

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