Row Compression and Nested Product Decomposition of a Hierarchical Representation of a Quasiseparable Matrix

Ph.D. Dissertation Proposal

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This research introduces a row compression and nested product decomposition of an $n \times n$ hierarchical representation of a rank structured matrix A which extends the compression and nested product decomposition of quasiseparable matrices. The hierarchical parameter extraction algorithm of a quasiseparable matrix is efficient requiring only $O(n \log n)$ operations, and is backward stable. The row compression is comprised of a sequence of small Householder transformations which are formed from the low-rank off-diagonal blocks of the hierarchical representation of a rank structured matrix. The row compression forms a factorization of matrix $A = QC$, where Q is the product of the Householder transformations, and C preserves the low-rank structure in both the lower and upper triangular parts of the matrix A. The nested product decomposition is formed after applying a sequence of unitary transformations to the compressed matrix C. Both the compression and decomposition are stable, and require $O(n^2)$ operations. At this point, the matrix-vector product and solver algorithms are the only ones fully proven to be backward stable for quasiseparable matrices. By combining a fast matrix-vector product and system solver, linear systems involving the decomposition are directly solved with linear complexity. An application of the hierarchical representation of quasiseparable matrices in image processing will be shown.

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