Oscillatory Integral Operators and Interpolative Butterfly Factorization

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The far-field interactions of some oscillatory integral operators can be represented by a matrix that satisfy a complementary low-rank property. In this talk, we introduce a interpolative butterfly factorization for such matrices. A preliminary interpolative butterfly factorization is first constructed based on interpolative low-rank approximations. A novel sweeping matrix compression technique further compresses the preliminary interpolative butterfly factorization via a sequence of structure-preserving low-rank approximations. The sweeping procedure propagates the low-rank property among neighboring matrix factors to compress dense submatrices in the preliminary butterfly factorization to obtain an optimal one in the butterfly scheme. For an $N \times N$ matrix, it takes $O(N \log N)$ operations and complexity to construct the factorization as a product of $O(\log N)$ sparse matrices, each with $O(N)$ nonzero entries. Hence, it can be applied rapidly in $O(N \log N)$ operations. Numerical results are provided to demonstrate the effectiveness of this algorithm.

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