Fast Energetic BEM for time-domain acoustic and elastic 2D scattering problems

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We consider acoustic and elastic wave propagation problems in 2D unbounded domains, reformulated in terms of space-time Boundary Integral Equations (BIEs). The BIEs are set in a weak form related to the energy of the system and then discretized by a Galerkin-type Boundary Element Method (BEM): this approach, called Energetic BEM, has revealed accurate and stable even on large time intervals of analysis [1, 2].
The Energetic BEM matrices have a Toeplitz lower triangular block structure, where blocks, generated using standard Lagrangian piecewise polynomial space basis functions, become fully populated for growing time; hence the overall memory cost of the energetic BEM is $O(M^2N)$, M and N being the number of the space degrees of freedom and the total number of performed time steps, respectively. This can be a drawback for the application of such method to large scale problems. To overcome this issue, we have proposed in [3] a fast technique based on the Adaptive Cross Approximation (ACA). Indeed, the core of this procedure is the approximation of sufficiently large time blocks of the energetic BEM matrix through the partially pivoted ACA algorithm introduced in [4], which allows to compute only few of the original entries. This leads to reduced assembly time, which for the energetic BEM is generally relevant, coupled with reduced memory storage requirements. Additionally, the consequent acceleration of the matrix/vector multiplication together with a marching on time procedure, leads to remarkable reduction of the computational solution time. The effectiveness of the proposed method is theoretically proved and several numerical results are presented and discussed, with some further advancements.

References

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