ENERGETIC BOUNDARY ELEMENT METHOD FOR 2D ELASTODYNAMICS PROBLEMS IN TIME DOMAIN

GIULIA DI CREDICO

In this presentation I will provide an overview on the theoretical and numerical aspects involved in the application of the Energetic Boundary Element Method (Energetic BEM) to the resolution of 2D elastodynamic problems in exterior unbounded domains [1]. This method implies the reformulation of the related differential problem in terms of *Boundary Integral Equations* (BIEs), which depend on characteristic integral operators and are suitable to solve problems equipped by Dirichlet or Neumann datum at the boundary. A space-time approach is considered, then the BIEs are reformulated in a weak form, based on energy arguments, and numerically solved by means of the Energetic BEM. This approach ensures a good theoretical setting in case of single layer weak formulations, leading to an accurate and stable in time resolution of the BIEs and to a precise approximation of the external unknown displacement. Several numerical tests will be therefore presented and discussed: the correctness of the Energetic BEM implementation is in particular proved showing the convergence in time of solutions of specific indirect BIEs towards analytical elastostatic functions, these latter calculated on the base of the datum imposed on a straight open obstacle. With other numerical results we moreover aim to study the decay of the energetic approximation errors obtained with the use of *hp* and *graded meshes*, useful to refine the boundary of a polygonal domain towards critical corner points where the BIEs solutions are featured by a singular behaviour [4].

The presentation will also take into consideration the numerical aspects entailed by the discretization of the energetic weak formulations, for which solving the integral problem becomes equivalent to the resolution of a linear system, where the block Toeplitz structured matrix has entries represented by quadruple space-time integrals: the accurate numerical computation of these elements is a crucial phase for the Energetic BEM implementation, especially because of the peculiar spatial singularities characterizing the related integral kernel [2, 3].

In the end I will discuss a strategy to reduce the computational costs of the Energetic BEM in case of large scale acoustic and elastodynamic wave propagation problems [5]. Thanks to a compression technique based on the *Adaptive Cross Approximation* (ACA), I will show a remarkable reduction in the assembly time of the linear system and in the memory requirements for the storage of the Toeplitz matrix, without altering the precision of the numerical results.

This is a joint work with Alessandra Aimi, Mauro Diligenti, Chiara Guardasoni [2, 3], Heiko Gimperlein, Ernst P. Stephan [4] and Luca Desiderio [5].

REFERENCES

[1] A. AIMI, L. DESIDERIO, M. DILIGENTI & C. GUARDASONI, *Application of Energetic BEM to 2D Elastodynamic Soft Scattering Problems*, CAIM, 10 (1) (2019): 182-198.

[2] G. DI CREDICO, A. AIMI & C. GUARDASONI, *Energetic Galerkin Boundary Element Method for 2D Elastodynamics: integral operators with weak and strong singularities*, BE-MRM XLIV, 131 (2021): 17-29.

[3] A. AIMI, G. DI CREDICO, M. DILIGENTI & C. GUARDASONI, *Highly accurate quadrature schemes for singular integrals in energetic BEM applied to elastodynamics*, JCAM, 410 (2022), 114186.

[4] A. AIMI, G. DI CREDICO, H. GIMPERLEIN & E.P. STEPHAN, *Higher-order time domain boundary elements for elastodynamics - graded meshes and hp-versions*, (2021, under review).

[5] A. AIMI, L. DESIDERIO & G. DI CREDICO, *Partially pivoted ACA based acceleration of the Energetic BEM for time-domain acoustic and elastic waves exterior problems*, (2021, under review).

DEPARTMENT OF MATHEMATICAL, PHYSICAL AND COMPUTER SCIENCES, UNIVERSITY OF PARMA, ITALY
Email address: giulia.dicredico@unipr.it