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The mortar element method as an effective tool for solving large scale dynamic soil-structure interaction problems

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Mortar element techniques, firstly proposed by Bernardi, Maday and Patera (Bernardi et al., 1994), allow an efficient coupling of different physical models, discretization schemes or non-matching triangulations in the non-overlapping subdomains. The main feature of the mortar element method is to replace the exact continuity condition at the skeleton of the decomposition with a weak one, that can be written in terms of a Lagrange multiplier and the jump of the traces. Quadrature formulas are used to evaluate the associated integrals, involving discrete functions defined on different non-matching grids or of different polynomial degree. Due to its high flexibility, this approach has been analysed and implemented in many situations.
In the present work, we consider the Mortar Spectral Element Method (MSEM) coupled to finite differences to simulate the propagation of elastic waves in complex unbounded media.
Our formulation is designed for the general case: a geometrically non-conforming domain partition where local meshes are independently generated from the neighbouring ones and associated with different spectral approximation degrees. We thus subdivide the domain into "n" non-overlapping subregions "Omega_k", and in each "Omega_k" the grid is assumed to be conforming. Note that the subdomain partition is constructed according to the (available) material properties, and is supposed to satisfy suitable regularity (standard) assumptions. The resulting skeleton, i.e. the intersection of subdomain boundaries, is then decomposed into mortar elements that are (d-1)-dimensional geometrical entities for a d-dimensional problem. Each subregion can have different polynomial approximation orders and the coupling between possible discontinuities is handled by mortars.

In this contribution we present a first set of benchmark assessing the accuracy and flexibility of the previous method, implemented in the well known spectral elements based code GeoELSE (Faccioli et al., 1997 and Stupazzini et al., 2009). Furthermore we illustrate how this recent enhancement of GeoELSE can be effectively used also for the numerical analysis of DSSI problems, with reference to the 2D seismic response of a railway viaduct in Italy. This numerical analysis includes the combined effect of: a) strong lateral variations of soil properties; b) topographic amplification; c) DSSI; d) spatial variation of earthquake ground motion in the structural response. Some hints on the work in progress to effectively handle 3D problems with MEM are also given.

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