Performance of time-harmonic wave modeling and inversion using Hybridizable Discontinuous Galerkin discretization and the MUMPS solver

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Abstract

In this work, we perform large-scale numerical simulations of time-harmonic wave propagation and inversion in the context of acoustic and elastic media for applications such as seismic imaging and helioseismology. We investigate the efficiency of our numerical methodology based upon two factors.

Firstly, we use the hybridizable discontinuous Galerkin method (HDG) for the discretization of the waves partial differential equations. By using a mixed formulation coupled with static condensation, HDG generates systems of sparse linear equations which are smaller than other discretization methods and we show a reduction in the size of the global matrix by a factor 3 to 7. Furthermore, these systems have multiple sparse right-hand sides associated with several sources, motivating the use of direct solver.

Therefore, the second aspect to control the numerical cost is using solver MUMPS to solve the resulting linear system. In particular, the computational time and memory footprint are reduced with (1) the analysis by blocks that efficiently uses the specificity of the HDG matrix structures, (2) the low-rank property and the Block-Low Rank (BLR) format to reduce asymptotic complexity and (3) exploiting lower precision formats (such as 24 and 16 bit arithmetics) in the representation of BLR blocks, where one key is to ensure satisfactory accuracy.

In this presentation, we illustrate with experiments in three dimensions for wave modeling and inversion, using the parallel code hawen (`https://ffaucher.gitlab.io/hawen-website/`).