Multi-Scale S-Fraction Reduced-Order Models for Massive Wavefield Simulations

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We present a reduced-order multi-scale method for solving large time-domain wavefield simulation problems. The algorithm consists of two main stages. During the first “off-line” stage the computational domain is split into multiple subdomains. Then projection-type multi-scale reduced order models (ROMs) are computed for the partitioned operators at each subdomain. The off-line stage is “embarrassingly” parallel as ROM computations for the subdomains are independent of each other. It also does not depend on the number of simulated right-hand sides and it is performed just once before the entire time-domain simulation. At the second “on-line” stage the time-domain simulation is performed within the obtained multi-scale ROM framework. The crucial feature of our formulation is the representation of the ROMs in terms of matrix Stieltjes continued fractions (S-fractions). This allows us to sparsify the obtained multi-scale subdomain operator ROMs and to reduce both the computational cost and communications which is highly beneficial for serial as well as parallel implementations of the on-line stage. The performance of the method is illustrated on 3*D* composite anisotropic elastic problems.