On a Simpler Way of Simulating Wave Dynamics in Complex Geometrical Conditions

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Recent advances in computational technologies have made it possible to simulate rather complex physical phenomena even on a PC basis. Typical numerical methods used in geophysics and solid mechanics are finite difference method (FDM), finite element method (FEM) and boundary element method (BEM). For wave and fracture dynamics, FDM is computationally efficient but the geometry employed must be generally rather simple. If we have more complex geometries, FEM may be more appropriate, but caution should be exercised, e.g., regarding its mesh dependency. If we have infinitely extending media, then BEM may be more suitable, but we do need boundary integral equation (BIE) formulations usually involving some sophisticated mathematical treatment of singularities. In this contribution, we introduce a possibly simpler numerical scheme for wave dynamics based on the method of characteristics. The mathematical formulation is for one- and (in-plane) two-dimensional linear elastic media with/without interfaces between dissimilar materials, including stress-free/rigid boundaries (surfaces). By shifting the known information about physical quantities (generalized particle velocities and stresses) and their first spatial derivatives at a given time step with the local sound (P-/S-wave) velocities, we construct the distributions of those quantities efficiently for the next time step. By doing this, we may obtain more precisely the time-dependent distributions of stresses and particle velocities in linear elastic media. At first sight, the method resembles FDM, but in reality, for a given point considered, the formulation derived is not influenced by the exact positions of the surrounding grid points and therefore we may be able to simulate complicated wave problems with more complex geometrical conditions: The information at the previous time step can be taken virtually from every place in the media and therefore, restrictions regarding the positions of grid points (or mesh shape) and boundary geometry may be lessened compared with, e.g., finite difference method. The method suggested in this study may be applied in the field of seismology and solid mechanics as well as civil and mechanical engineering.