Application of the Biorthogonal Multi-Resolution Time Domain Method to Study Elastic-Wave Interactions With Buried Land Mines

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Electromagnetic waves are very effective in detecting buried land mines. However, if the permittivity of the land mine (plastic mines, for example) is very close to the soil permittivity, or the conductivity of the soil is high, the scattered fields will be very weak. It will be very difficult to detect the land mines. In this case, elastic waves are very promising and show great advantages. Elastic waves interact with the land mines and cause the mines and the surface above the mines to vibrate, and the vibration can be detected thus the mines can be located.

The elastic wave motion in a medium can be described by a set of first-order partial differential equations according to the equation of motion and the stress-strain relation. Thus the finite-difference time-domain (FDTD) modeling scheme can be naturally applied for this issue to explore the mine-wave interactions. Similar to the FDTD method for electromagnetic wave applications, the advantage of such implementation is that it can deal with complex-shaped, homogeneous or inhomogeneous targets. Also it has a poor numerical dispersion property, which means the fields must be over-sampled to obtain accurate results.

In this paper we will introduce biorthogonal multi-resolution time domain (Bi-MRTD) method to this field. A perfectly matched layer surrounding the discretized solution space is also implemented to absorb the outgoing waves. Numerical results show that the numerical dispersion properties can be improved significantly by using biorthogonal wavelets as bases, which means larger problem can be considered with the same computational resources.

To further increase the ability of the model, the message-passing interface (MPI) is used to parallelize the algorithm.