A smoothed finite element method for underwater acoustic scattering problems in two dimensions

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Abstract

In this work, a smoothed finite element method (SFEM), in which the gradient smoothing technique (GST) from meshfree methods is incorporated into the standard Galerkin variational equation, is proposed to handle the acoustic wave scattering by the obstacles immersed in water. In the SFEM model, only the values of shape functions, not the derivatives at the quadrature points are required and no coordinate transformation is needed to perform the numerical integration. Due to the softening effects provided by the GST, the original "overly-stiff" FEM model has been properly softened and a more appropriate stiffness of the continuous system can be obtained, then the numerical dispersion error for the acoustic problems is decreased conspicuously and the quality of the numerical solutions can be improved significantly. To tackle the exterior Helmholtz equation in unbounded domains, we use the well-known Dirichlet-to-Neumann (DtN) map to guarantee that there are no spurious reflecting waves from the far field. Numerical tests show that the present SFEM cum DtN map (SFEM-DtN) works well for exterior Helmholtz equation and can provide better solutions than standard FEM.

Keywords: Gradient smoothing technique (GST); Unbounded domains; Numerical method; Helmholtz equation; Underwater acoustic scattering.