An Accelerated Grid-based BEM for Geometrically Nonlinear Elastic Problems

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Abstract

Benefited from the reduced dimensionality and the fundamental solutions, the boundary element method (BEM) has been firmly established as an effective method for solving engineering problems with complex 3-D geometries. For non-homogeneous and/or nonlinear problems, a major difficulty for the BEM to be competitive with other methods is to find an efficient and accurate way to evaluate the volume integrals containing the nonhomogeneous /nonlinear term in the integral formulation. A grid-based direct volume integration method has recently been proposed and has been applied for solving nonlinear Laplace problems [1-3] and non-homogeneous elasticity problems [4]. With the aid of "Galerkin vectors", the volume integral is exactly decomposed into a (non-singular) boundary integral, and a volume integral that can be simply and accurately evaluated using a regular grid overlaying the problem domain.

In this work, the grid direct volume integration method is extended to 3-D geometrically nonlinear elastic problems. Integral equations with volume integrals taking into account the geometrical nonlinearities are firstly derived. Utilizing "Galerkin vectors" for elasticity [4], these volume integrals are then decomposed into boundary integrals and volume integrals that are defined on a cuboid. The integral equations are then numerically solved using a collocation method accelerated with pre-corrected FFT technique. Several 3-D examples will be presented to demonstrate the accuracy of the formulation and numerical implementation. Implementation issues such as the regularizations of strong singular and hypersingular boundary integrals, as well as strongly singular domain integrals will also be discussed.

Keywords: BEM, Regular grid, Volume integrals, Nonlinear Elasticity.

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