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A collocation BEM for 3D acoustic problems based on a non-singular Burton-Miller formulation with linear continuous elements

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Abstract:

It is well known that Burton-Miller formulation can overcome the problems of non-unique solutions of exterior problems at the fictitious frequencies of the corresponding interior problems. However, the increased singularity involved in the Burton-Miller formulation is one of the crucial troublesomeness in the implementation of BEM with linear continuous element for 3D acoustic problems. Among the prevailing regularization methods, analytical evaluation of the singular integrals is a more attractive option due to the higher accuracy and less computational cost. In this work, an explicitly non-singular Burton-Miller formulation is developed for the model discretized with planar triangular elements. To facilitate the derivation of non-singular expressions, an integration method based on the vertexes' coordinates of the element is applied to the singular integrals. A collocation approach, which does not put the collocation points overlap with the nodes, is proposed to guarantee a $C^{1,a}$ Hölder continuity for canceling out the divergent terms appeared in obtaining the non-singular expression. By expanding the exponent function in the integrand into a Taylor series, analytical expressions are derived for the generic line integrals left in the non-singular Burton-Miller formulation with respective to the polar angle. At last, a collocation BEM with linear continuous element is built for 3D acoustic problems, which is more accurate and efficient in solution, as well as less in memory consumption than that of the BEM with constant element. Numerical examples are elaborately designed to validate the formulations and procedure of the linear BEM.

Keywords: boundary element method, linear continuous element, Burton-Miller formulations, hyper singular integral, Helmholtz equation