A Modal Boundary Element Method for Laplace problems

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The boundary element method for three dimensional acoustic propagation and radiation problems is based on the three dimensional Laplace equation and its fundamental solution. It is written in terms of the three dimensional Green function and its normal derivative. In order to simplify the axisymmetric acoustic problem, a modal boundary element method can be used. It is based on the modal Green function and its modal normal derivative. The modal terms are the Fourier coefficient of the three dimensional terms. The modal boundary element method has two difficulties of the singularity and stability problems. In the classical axisymmetric formulation, the singularity problem is evaluated by a numerical integral. The stability problem is solved by analytical methods based on the recursive formula and the fast Fourier transform which contain additionally terms.
In this paper, we present a new method for obtaining the conventional modal boundary element method applied for the axisymmetric radiation and propagation problems. In order to reduce the computational burden of the classical BEM, the singularity problem due to a source point is taken on the generator at an observer point is solved by an analytical free term. It is based on the angle in the meridian plane. Additionally, the stability problem is solved by a simple analytical recursive formula based on the Laplace coefficients and expressed only in terms of complete elliptic integrals. The proposed formulation is validated by a comparison with analytical solution of the acoustic sources and with Finite Element Method for rigid duct.