A HYBRID METHOD FOR THE GEOMETRIC AND MATERIAL RECONSTRUCTION OF SUBSURFACE OBSTACLES USING ELASTIC WAVES

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The focus of this study is a development of the systematic probe method for solving inverse scattering problems in near-field elastodynamics. The proposed methodology involves a sequential deployment of two recent sampling reconstruction techniques, namely the linear sampling method (LSM) and the topological sensitivity approach (TSA). The former technique [1,2] is based on a linear integral equation of the first kind whose solution becomes unbounded as the (sampling) source point of the reference Green's function, featuring the right-hand side, approaches the boundary of an elastic scatterer from its interior. The LSM has been the subject of mounting attention in near-field elastodynamics [3,4] due to its remarkable simplicity and apparent independence from the boundary conditions characterizing the scatterer's surface. Accordingly, it is well suited for the geometric reconstruction of subsurface obstacles when the material characteristics thereof are unknown. The second technique [5,6] is based on the concept of topological derivative that characterizes the first-order Taylor expansion (written in terms of the defect size) of the scattered field caused by a small elastic inclusion. Even though a recent study suggests [7] that the TSA alone can be used for both geometric and material characterization of inner defects, a computational comparison between the LSM and TSA reveals that the former technique may be better suited for geometric identification as it produces more accurate images at a reduced computational cost. Accordingly, this study investigates the possibility of a hybrid reconstruction approach where the geometric identification stage, effected via the LSM, is followed by its material characterization counterpart in terms of the TSA. In the second stage, a geometric information stemming from the LSM is employed to calculate the first-order Taylor expansion of the scattered field as an explicit algebraic function of the (unknown) material characteristics of subsurface defects, namely their shear modulus, bulk modulus, and mass density. This leads to a non-linear system of equations in terms of the latter parameters that can be effectively solved using standard minimization techniques. A set of reconstruction results based on synthetically-generated measurements is presented to illustrate the performance of hybrid methodology.

References

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