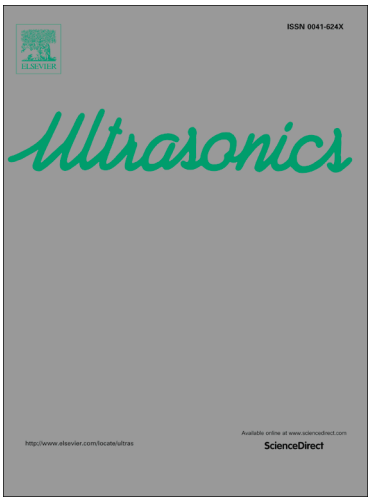

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Characterization and prediction of the backscattered form function of an immersed cylindrical shell using hybrid fuzzy clustering and bio-inspired algorithms

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Abstract

The acoustic scattering of a plane wave by an elastic cylindrical shell is studied. A new approach is developed to predict the form function of an immersed cylindrical shell of the radius ratio b/a ('b' is the inner radius and 'a' is the outer radius). The prediction of the backscattered form function is investigated by a combined approach between fuzzy clustering algorithms and bio-inspired algorithms. Four famous fuzzy clustering algorithms: the fuzzy c-means (FCM), the Gustafson-Kessel algorithm (GK), the fuzzy c-regression model (FCRM) and the Gath-Geva algorithm (GG) are combined with particle swarm optimization and genetic algorithm. The symmetric and antisymmetric circumferential waves A, S_0, A_1, S_1 and S_2 are investigated in a reduced frequency (k_1a) range extends over $0.1 < k_1a < 225$ (k_1 is the wave number). The time-frequency representation of Smoothed Pseudo Wigner-Ville (SPWV) is applied on the predicted and calculated acoustic backscattered form functions. This representation is used as a comparison criterion between the calculated form function by the analytical method and that predicted by the proposed approach on the one hand and is used to extract the predicted cut-off frequencies on the other hand. Moreover, the transverse velocity of the material constituting the cylindrical shell is extracted. The computational results show that the proposed approach is very efficient to predict the form function and consequently, for acoustic characterization purposes.

Keywords: Acoustic scattering; circumferential waves; acoustic characterization; time-frequency representation; soft computing algorithms.

1. Introduction

The acoustic scattering techniques are very practical in many fields due to their ability to extract the information about the target without any damage [1–8]. Several theoretical and experimental studies have used these techniques to characterize an immersed elastic cylindrical shell [9–14]. The study of the acoustic scattering of a plane wave by a cylindrical shell immersed in water shows that many waves are generated in the cylindrical shell and on the interface cylindrical shell/water. These waves are generated due to the interaction between the incident plane wave with the material constituting the cylindrical shell. In normal incidence, the different generated waves are classified into [10, 11, 14, 15]: the Antisymmetric circumferential waves (A and A_i, with i=0,1,..., is the wave index), the Symmetric circumferential waves (S_i) and the reflective waves on the outer interface of the shell. The antisymmetric waves are coming from the antisymmetric vibrations of the inner and outer parts of the shell. The symmetric waves are coming form the symmetric vibrations. The propagation of the circumferential waves leads to create the standing waves

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