Ultrasonic echo data-driven method for intelligent identification of material characteristic parameters

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Abstract

Reliable specification of material characteristic parameters is crucial in structural performance and reliability assessment, but existing methods often have limitations in practical applications and are greatly restricted by uncertainties, such as ambiguous boundaries, variable thickness, and non-uniform material properties. For this reason, a method for identifying material characteristic parameters by ultrasonic echoes and artificial neural networks (ANN) is developed for the first time in this paper. The ultrasonic echo waveform is used as the input to the ANN model, and the characteristic parameters of the material under test are output from the ANN. A generalized ultrasonic echo numerical model based on a single-crystal straight probe is developed to simulate the acquisition process of the echo signal, and a data-driven training sample numerical dataset is produced to train the ANN. Once the ANN is trained, the actual measured echo waveform can be used as the input to the ANN while identifying the material characteristic parameters of the material. In the echo signal preprocessing, the feature preference algorithm designed in this paper compares with the commonly used normalization processing and PCA dimensionality reduction methods, the feature information loss of this method is smaller, which effectively improves the recognition accuracy of the inverse problem. In addition, the intelligent identification method of material feature parameters proposed in this paper can be further extended to the prediction of other types of nonlinear material feature parameters, which has a broader application prospect.

Keywords: Computational inverse; material parameter identification; ultrasonic echo; feature preference; Artificial neural network