Defects classification based on the combination of improved ultrasonic measurement model and artificial neural network

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Scanning acoustic microscopy (SAM) is a high-precision non-destructive testing equipment, which is widely used in various fields, such as material characterization, defect detection and living cell observation. However, evaluation of testing results automatically is still a challenge due to the need for a large number of labeled experimental data. In this work, a novel method to identify inclusions and holes in metallic materials using SAM is proposed based on the combination of the improved ultrasonic measurement model (IUMM) and artificial neural network (ANN). A hybrid model of Born approximation and Kirchhoff approximation is developed to calculate the far-field scattering amplitude, which improves the accuracy in phase and amplitude of the predicted pulse-echo signals of defects. The ANN classifier, with the amplitude and peak frequency of the predicted echo signals as features, is applied to distinguish inclusions and holes. The experimental result on the bearing steel shows that the echo signals predicted by the proposed IUMM are more accurate than conventional UMM. The ANN classifier, with the predicted signals as training set, enables the identification of inclusions and holes in metallic materials successfully. This work improves the performance of SAM in the identification of internal defects in metallic materials and demonstrates the potential of the combination of theoretical models and machine learning methods in the intelligent non-destructive evaluation.