AI-based Model to Estimate the Flaws from Ultrasonic NDT Data

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In nondestructive testing (NDT), geometrical features of a flaw embedded in the material, including its location, length, and orientation angle, are critical factors to assess the severity of the flaw and to make post-manufacturing decisions. In this study, artificial intelligence (AI) based approach was applied to the oscillograms from ultrasonic NDT to estimate geometrical features of a flaw. To this end, a gradient-based optimization algorithm which is called backpropagation (BP) was implemented to train a multilayer perceptron artificial neural network (MLPANN) to estimate the flaw's geometrical characteristics (MLPANNBP). First, an acoustic model of specimen was constructed by using actual acoustic parameters data. The model was validated by conducting the experiments using the specimens without and with defects. Then, 750 specimen models including flaws with different locations, lengths, and angles were generated by COMSOL. Next, the oscillograms produced by the models were divided into 3 categories: 525 as training dataset, 113 as validation dataset, and 112 samples as testing dataset. Training inputs of the network were parameters extracted from ultrasonic signals which were received through ultrasonic receiver. Lastly, to evaluate the MLPANNBP performance, outputs of the network including flaw's location, length, and angle were compared with the desired values for all training, validation, and testing dataset. Deviations of the outputs from desired values were calculated by a regression analysis. Statistical analysis was also performed by measuring Root Mean Square Error (RMSE) and Efficiency (E). RMSE in x-location, y-location, length, and angle estimations are 0.49 mm, 0.53 mm, 0.31 mm, and 5.37 deg, with efficiencies of 0.9829, 0.9745, 0.9583, and 0.9614, respectively, for the testing dataset, which are better than the existing methods. Results suggest that the proposed AI-based MLPANNBP can be used to characterize flaws with transmit/receive NDT approach.