Ultrasonic reconstruction of rough surface morphology using deep learning method

Zhengjun Wang[1], Fan Shi[2], Fangxin Zou[3]

[1]MAE, Hong Kong University of Science and Technology, Hong Kong, [1]Department of Mechanical and Aerospace Engineering,, Hong Kong University of Science and Technology, Hong Kong, [1]Department of Aeronautical and Aviation Engineering, The Hong Kong Polytechnic University, Hong Kong

Realistic cracks and corrosion surfaces exhibit intricate and rough morphologies, which have a profound impact on the behavior of ultrasonic scattered waves. The inspection and imaging of such rough surface profiles pose significant challenges, primarily stemming from a lack of fundamental understanding of the complex wave behavior involved. We present a methodology that utilizes a one-dimensional convolutional neural network (1DCNN) to recover the morphology of a complex rough surface from ultrasonic pulse echo measurements obtained with an array of equidistant sensors. The neural network is trained using datasets generated from high-fidelity finite element simulations, encompassing a range of roughness parameters. The trained model is then evaluated using both numerical and real experimental data. Performance assessment of our proposed method involves comparing the rough surface reconstruction results obtained from the deep learning approach with those achieved through conventional ultrasonic array imaging methods such as TFM method. Unlike array imaging-based techniques that necessitate a large number of sensors (e.g., 128, 64, or 32), the deep learning-based approach utilizes pulse echo signals and achieves highly accurate results with significantly fewer sensors (e.g., 8, or 4). This development in deep learning has the potential to enable cost-effective, and real-time reconstruction of complex surface profiles.