Deep learning-based infrared thermographic defect detection in complex-shaped CFRP

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As artificial intelligent (AI) technology develops, neural networks, and more complex deep learning algorithms have come to be used in nondestructive testing and evaluation [1]. As we know, human interpretation is subjective, sometimes it is inconsistent or even biased. AI platform to detect or estimate defects could be even more automated and reliable. Deep learning algorithms are known for their abilities to learn and model non-linear and complex relationships. In this paper, we focus on the influence of surface shape on the testing results obtained from deep learning model for infrared thermographic data. With the rapid development of aerospace industry, large complex-shaped components are more and more widely used. When performing non-destructive testing on complex-shaped parts using active infrared thermography, some regions receive more stimulation energy and emit more infrared radiation which can be detected by an infrared camera. In other words, the shape of the component significantly affect the inspection results in active infrared thermography. In this study, we inspected three carbon fiber reinforced plastic (CFRP) samples by pulsed infrared thermography. The three samples are different shapes, which are flat, curved and trapezoid. The thermographic signal reconstruction (TSR) and 1st derivative (1D) which was first proposed by Dr. Shepard [2] was used to process the thermographic data. In pulsed thermography, each point on the sample corresponds to a specific cooling process. We automatically classified defective and non-defective points via long short term memory recurrent neural network (LSTM-RNN). RNN is a state-of-the-art deep learning algorithm which was designed for temporal sequences [3]. LSTM is proposed to tackle the problem of gradient vanishing for long durations. The testing results of LSTM-RNN model were compared with the results from neural network (NN) model. The comparison results showed that for complex-shaped samples, the LSTM-RNN model obtained better detection results than NN model. The component shape had little influence on the testing result of LSTM-RNN model using TSR and 1st derivative as input signal. References [1] Duan Y, Liu S, Hu C, Hu J, Zhang H, Yan Y, Tao N, Zhang C, Maldague X, Fang Q, Ibarra-Castanedo C, Chen D, Li X, Meng J. Automated defect classification in infrared thermography based on a neural network. NDT and E International 2019, 107:102147. [2] Shepard SM, Lhota JR. Reconstruction and enhancement of active thermographic image sequences. Optical Engineering 2003, 45:1337–42. [3] Hu C, Duan Y, Liu S, Yan Y, Tao N, Osman A, Ibarra-Castanedo C, Sfarra S, Chen D, Zhang C. LSTM-RNN-based defect classification in honeycomb structures using infrared thermography. Infrared Physics & Technology 2019, 102:103032.